67th Annual Meeting of the North Central Weed Science Society

December 10-13, 2012
Hyatt Regency at the Arch
St. Louis, MO

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.

General Session

Cahokia Mounds: An Ancient City Made Possible by Grasses and Weeds. Bill Iseminger*; Cahokia Mounds State Historic Site, Collinsville, IL

Where Has Weed Science Been and Where is it Going? Perspective of a "Mature" Weed Scientist. Dale Shaner*; USDA, Fort Collins, CO (87)

Washington Report. Lee Van Wychen*; WSSA, Washington, DC

CAST Report. Duane Rathmann*; BASF Corp., Waseca, MN (89)

NCWSS Presidential Address. Bryan G. Young*; Southern Illinois University, Carbondale, IL

Necrology Report. Aaron G. Hager*; University of Illinois, Urbana, IL

Cereals/Sugar Beet/Dry Bean

Wheat Impacts Control of Horseweed (*Conyza canadensis*) and Giant Ragweed (*Ambrosia trifida*). James R. Martin*, Jesse L. Gray, Dorothy L. Call; University of Kentucky, Princeton, KY (1)

Spring Wheat Yield after Glyphosate Exposure at Emergence. Mike J. Moechnig*, Darrell L. Deneke, David A. Vos, Jill K. Alms; South Dakota State University, Brookings, SD (2)

†Wheat Response to Glyphosate Drift or Contamination. Andrew N. Fillmore*, Kirk A. Howatt; NDSU, Fargo, ND (3)

†Volunteer Corn Reduces Yield in Sugarbeet. Christy Sprague, Amanda C. Harden*; Michigan State University, East Lansing, MI (127)

Corn/Sorghum

Control of HPPD-Resistant Waterhemp in Corn and Soybean. Neha Rana*[1], 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 (4)

Control of HPPD-Resistant Waterhemp with Mesotrione and Tankmixes Applied Preemergence. Neha Rana*[1], 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 (5)

Enlist™ Ahead. Joe Armstrong*[1], Tami Jones-Jefferson[2], Mark A. Peterson[2], David E. Hillger[2], Jonathan A. Huff[3]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Herrin, IL (6)

Agronomic Performance of Enlist™ Corn. David M. Simpson*[1], Jim W. Bing[1], Scott C. Ditmarsen[2], Doug J. Spaunhorst[3], Neil A. Spomer[4]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Madison, WI, [3]University of Missouri-Columbia, Columbia, MO, [4]Dow AgroSciences, Brookings, SD (7)

†The Influence of 2,4-D and Drift Reduction Technologies on the Efficacy of Glyphosate or Glufosinate on Fall Panicum. Lucas A. Harre*, Bryan G. Young, Joesph L. Matthews, Julie M. Young; Southern Illinois University, Carbondale, IL (8)

Volunteer Soybean Competition and Control in Corn. Jill K. Alms*, David A. Vos, Mike J. Moechnig, Darrell L. Deneke; South Dakota State University, Brookings, SD (9)

Dandelion Competition in Corn. David A. Vos*, Jill K. Alms, Mike J. Moechnig, Darrell L. Deneke; South Dakota State University, Brookings, SD (10)

†Tolerance of Seed Corn Inbreds to Postemergence Applications of Rimsulfuron + Mesotrione + Isoxadifen-ethyl or Nicosulfuron + Isoxadifen-ethyl. Nicholas R. Steppig*[1], Larry H. Hageman[2], Helen A. Flanigan[3], Patrick M. McMullan[4]; [1]DuPont Crop Protection, Rochelle, IL, [2]DuPont Crop Protection, ROCHELLE, IL, [3]DuPont, Greenwood, IN, [4]DuPont Pioneer, Johnston, IA (11)

†Controlling Glyphosate-Resistant Palmer amaranth Using Atrazine Tank Mixes in Corn. Matthew S. Wiggins*, Kelly A. Barnett, Lawrence E. Steckel; University of Tennessee, Jackson, TN (135)

Corn Tolerance to Single and Multiple Flaming. Stevan Z. Knezevic*[1], Avishek Datta[2], Strahinja V. Stepanovic[3], Dejan Nedeljkovic[4], Neha Rana[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska - Lincoln, Lincoln, NE, [4]University of Belgrade, Belgrade, Serbia (136)

†Investigations of Early-Season Herbicide and Fungicide Co-Applications in Corn. Craig B. Solomon*, Jimmy D. Wait, Kevin W. Bradley; University of Missouri, Columbia, MO (137)

†The Effect of Volunteer Corn Growing in Corn on Grain Quality and Mycotoxin Contamination. Vanessa L. Garner*, William G. Johnson, Paul T. Marquardt, Kiersten A. Wise; Purdue University, West Lafayette, IN (138)

Two-Pass Weed Control in Glyphosate-Resistant Corn - Efficacy, Environmental Impact, Yield and Profitability. Peter Sikkema*[1], Robert E. Nurse[2], Chris Gillard[3], Nader Soltani[3]; [1]University of Guelph - Ridgetown Campus, Ridgetown, ON, [2]Agriculture and Agri-Food Canada, Harrow, ON, [3]University of Guelph Ridgetown Campus, Ridgetown, ON (139)

Clethodim Dose Response Curves for Volunteer Corn Control and Corn Injury After an Immediate Replant. Randall S. Currie*; Kansas State Univ., Garden City, KS (140)

Effects of Flaming and Cultivation on Weed Control and Yield in Organic Corn as Influenced by Manure Application. Strahinja V. Stepanovic*[1], Avishek Datta[2], Neha Rana[3], Brian D. Neilson[4], Chris Bruening[1], George Gogos[1], Stevan Z. Knezevic[3]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska-Lincoln, Lincoln, NE (145)

HPPD Resistance Testing in the Midwest-Preliminary Field Bioassay Results. Brent Philbrook*[1], Thomas Wilde[2], Roland Beffa[2], Thomas Kleven[3], Harry J. Strek[2]; [1]Bayer CropScience, White Heath, IL, [2]Bayer CropScience, Frankfurt, Germany, [3]Bayer CropScience, Sabin, MN (186)

U.S. University Herbicide Efficacy Studies Analysis: Corn and Sorghum Yield with Atrazine Versus Atrazine Alternatives: 2006-2010. Richard S. Fawcett*; Fawcett Consulting, Huxley, IA (187)

Burndown and Preemergence Weed Control with Rimsulfuron and mesotrione. Helen A. Flanigan*[1], Kevin L. Hahn[2]; [1]DuPont, Greenwood, IN, [2]DuPont, Bloomington, IL (188)

Enlist^{TM} Corn Tolerance to Enlist^{TM} Duo Applied from V3 Through V7 Growth Stages. Neil A. Spomer[1], David C. Ruen*[2], Bradley W. Hopkins[3], Kevin D. Johnson[4], Brian D. Olson[5]; [1]Dow AgroSciences, Brookings, SD, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Westerville, OH, [4]Dow AgroSciences, Danville, IL, [5]Dow AgroSciences, Geneva, NY (189)

Weed Control Programs in Enlist^{TM} Corn. Joe Armstrong*[1], Scott C. Ditmarsen[2], Fikru F. Haile[3], Jeff M. Ellis[4], Jonathan A. Huff[5], Eric F. Scherder[6]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Madison, WI, [3]Dow AgroSciences, Indianapolis, IN, [4]Dow AgroSciences, Smithville, MO, [5]Dow AgroSciences, Herrin, IL, [6]Dow AgroSciences, Huxley, IA (190)

Soybeans/Legumes

†Survey of Giant Ragweed Infestation Levels in Ohio Soybean Fields. JD Bethel*, Mark M. Loux, Jason T. Parrish; The Ohio State University, Columbus, OH (12)

Residual Control of Waterhemp with Dicamba. Seth T. Logan*[1], Bryan G. Young[2], Sara M. Allen[3]; [1]Monsanto Company, Pinckneyville, IL, [2]Southern Illinois University, Carbondale, IL, [3]Monsanto Company, St. Louis, MO (13)

Perceived Likelihood for Weeds to Evolve Resistance to Dicamba. Roberto J. Crespo[1], Mark L. Bernards*[2], Robert Peterson[3]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL, [3]Montana State University, Bozeman, MT (14)

Integration of Dicamba into Soybean (*Glycine max*) Production Systems for Control of Glyphosate-Resistant Palmer Amaranth (*Amaranthus palmeri*). Reid J. Smeda*[1], Lawrence E. Steckel[2], Simone Siefert-Higgins[3]; [1]University of Missouri, Columbia, MO, [2]University of Tennessee, Jackson, TN, [3]Monsanto, St. Louis, MO (15)

Dicamba Contributes Residual Weed Control to Roundup Ready® 2 Xtend Soybean Systems. John B. Willis*[1], Christopher D. Kamienski[2], Mayank S. Malik[3], Simone Siefert-Higgins[4]; [1]Monsanto, Hanson, KY, [2]Monsanto Company, Washington, IL, [3]Monsanto, Lincoln, NE, [4]Monsanto, St. Louis, MO (16)

Weed Control with BAS18322H in Corn and Dicamba-Tolerant Soybean. Jon E. Scott*[1], Leo D. Charvat[2], Neha Rana[1], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE (17)

Integrated Management of Difficult to Control Weeds in Dicamba Tolerant Soybeans in Nebraska. Jeffrey Golus*[1], Ryan S. Henry[2], Lowel Sandell[3], Mayank S. Malik[4], Simone Siefert-Higgins[5], Greg R. Kruger[2]; [1]University of Nebraska, Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]Monsanto, Lincoln, NE, [5]Monsanto, St. Louis, MO (18)

Performance of Commercial Track Glyphosate and Dicamba Tolerant Soybean Varieties. Cindy L. Arnevik*[1], Mindy Devries[2], Mark Lubbers[3], Joe Cordes[4]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto Company, Huxley, IA, [3]Monsanto Company, Wichita, KS, [4]Monsanto Company, Jerseyville, IL (19)

†Weed Control in Soybean as Influenced by Residual Herbicide Use and Glyphosate Application Timing Following Different Planting Dates. Ryan P. DeWerff*, Shawn P. Conley, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (20)

†Glufosinate with Tank Mixtures and Application Timing. Richard A. Weisz*[1], Rich Zollinger[1], Angela J. Kazmierczak[1], Devin A. Wirth[2]; [1]North Dakota State University, Fargo, ND, [2]NDSU, Fargo, ND

†Effectiveness of Combinations of Glyphosate and Glufosinate on Glyphosate-Resistant Horseweed. Tyler Johnson*, Mark M. Loux, Anthony Dobbels; The Ohio State University, Columbus, OH (22)

†Effect of Early-season Weed Control on Nutrient Competition and Yield in Soybean. Nick T. Harre*[1], Bryan G. Young[1], Scott Cully[2], Brett R. Miller[3], Mark Kitt[4]; [1]Southern Illinois University, Carbondale, IL, [2]Syngenta Crop Protection, Marion, IL, [3]Syngenta, Minnetonka, MN, [4]Syngenta Crop Protection, Minnetonka, MN (23)

†Efficacy of Preemergence Versus Postemergence Herbicides on Glyphosate-Resistant Horseweed (*Conyza canadensis*) in Soybean (*Glycine max*). Cody D. Cornelius*, Reid J. Smeda, Carey F. Page; University of Missouri, Columbia, MO (24)

†A Rapid, High-Throughput Molecular Assay for the Robust Genotypic Determination of Waterhemp Resistant to Protoporphyrinogen Oxidase (PPO)-Inhibiting Herbicides. R. Joseph Wuerffel*[1], Bryan G. Young[1], David A. Lightfoot[1], Patrick Tranel[2], Ahmad M. Fakhoury[1]; [1]Southern Illinois University, Carbondale, IL, [2]University of Illinois, Urbana, IL (25)

†Effects of Flaming and Cultivation on Weed Control and Yield in Organic Soybean as Influenced by Manure Application. Strahinja V. Stepanovic*[1], Avishek Datta[2], Neha Rana[3], Brian D. Neilson[4], Chris Bruening[1], George Gogos[1], Stevan Z. Knezevic[3]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska-Lincoln, Lincoln, NE (26)

Glyphosate-Resistant Giant Ragweed in Ontario. Nader Soltani*[1], Joanna Follings[2], Mark Lawton[3], François Tardif[2], Darren E. Robinson[4], Peter Sikkema[5]; [1]University of Guelph Ridgetown Campus, Ridgetown, ON, [2]University of Guelph, Guelph, ON, [3]Monsanto Canada, Guelph, ON, [4]University of Guelph, Ridgetown, ON, [5]University of Guelph - Ridgetown Campus, Ridgetown, ON (27)

Selectivity of an HPPD-Tolerant Soybean Event. Jayla Allen[1], John Hinz*[2], Michael L. Weber[3]; [1]Bayer CropScience, Research Triangle Park, NC, [2]Bayer CropScience, Story City, IA, [3]Bayer CropScience, Indianola, IA (28)

†Efficacy of PRE and POST Herbicides for Controlling Multiple-Resistant Palmer Amaranth in Michigan. David Powell*, Christy Sprague; Michigan State University, East Lansing, MI (29)

Glyphosate-Resistant Canada Fleabane in Ontario. Nader Soltani*[1], Holly P. Byker[2], Mark Lawton[3], Darren E. Robinson[4], François Tardif[5], Peter Sikkema[6]; [1]University of Guelph Ridgetown Campus, Ridgetown, ON, [2]University of Guelph, Ridgetown Campus, Ridgetown, ON, [3]Monsanto Canada, Guelph, ON, [4]University of Guelph, Ridgetown, ON, [5]University of Guelph, Guelph, ON, [6]University of Guelph - Ridgetown Campus, Ridgetown, ON (30)

†Soybean Response and Yield Implications of Postemergence Tank-mixtures in Glyphosate-Resistant Soybean. Theresa A. Reinhardt*[1], Bryan G. Young[1], Joesph L. Matthews[1], Julie M. Young[1], Douglas J. Maxwell[2], Aaron G. Hager[2], Mark L. Bernards[3]; [1]Southern Illinois University, Carbondale, IL, [2]University of Illinois, Urbana, IL, [3]Western Illinois University, Macomb, IL (31)

Preemergence Palmer Amaranth Control with Fierce™ Herbicide in US Soybean Production. Eric J. Ott*[1], Dawn Refsell[2], Trevor M. Dale[3], Gary W. Kirfman[4], John A. Pawlak[5]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA, Lathrop, MO, [3]Valent USA Corporation, Plymouth, MN, [4]Valent USA Corporation, Ada, MI, [5]Valent USA Corporation, Lansing, MI (32)

†Programs for the Management of Glyphosate-Resistant Waterhemp and Giant Ragweed in Dicamba-Resistant Soybean. Doug J. Spaunhorst*[1], Simone Seifert-Higgins[2], Christopher M. Mayo[3], Eric B. Riley[4], Kevin W. Bradley[4]; [1]University of Missouri-Columbia, Columbia, MO, [2]Monsanto Company, St. Louis, MO, [3]Monsanto Company, Gardner, KS, [4]University of Missouri, Columbia, MO (106)

†Impact of Plant Height on *Amaranthus* spp. Response to Dicamba. Ashley A. Schlichenmayer*[1], Reid J. Smeda[2]; [1]University of Missouri, Columbia, Columbia, MO, [2]University of Missouri, Columbia, MO (107)

Soybean Tolerance to Single and Multiple Flaming. Stevan Z. Knezevic*[1], Avishek Datta[2], Strahinja V. Stepanovic[3], Dejan Nedeljkovic[4], Nihat Tursun[5], Neha Rana[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska - Lincoln, Lincoln, NE, [4]University of Belgrade, Belgrade, Serbia, [5]Kahramanmaras Sutcu Imam University, Kahramanmaras, Turkmenistan (108)

†Investigations of Weed Management Programs for Use in Soybeans with Resistance to HPPD-Inhibiting Herbicides. John Schultz*[1], Michael L. Weber[2], Jayla Allen[3], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]Bayer CropScience, Indianola, IA, [3]Bayer CropScience, Research Triangle Park, NC (109)

†Control and Distribution of Glyphosate Resistant Giant Ragweed in Ontario. Joanna Follings*[1], Peter Sikkema[2], François Tardif[1], Darren E. Robinson[3], Mark Lawton[4]; [1]University of Guelph, Guelph, ON, [2]University of Guelph – Ridgetown Campus, Ridgetown, ON, [3]University of Guelph, Ridgetown, ON, [4]Monsanto Canada, Guelph, ON (110)

Comparison of Herbicide Programs in Glyphosate- and Glufosinate-Resistant Soybean.
Jeff M. Stachler*; NDSU and U. of MN, Fargo, ND (111)

†Systems for Management of Glyphosate-Resistant Horseweed in Soybeans. Bryan Reeb*, Mark M. Loux, Anthony Dobbels; The Ohio State University, Columbus, OH (112)

†Glyphosate Resistant Canada Fleabane (*Conyza canadensis*) in Ontario:Distribution and Control in Soybean (*Glycine max L.*). Holly P. Byker*[1], Peter Sikkema[2], François Tardif[3], Darren E. Robinson[4], Mark Lawton[5]; [1]University of Guelph, Ridgetown Campus, Ridgetown, ON, [2]University of Guelph - Ridgetown Campus, Ridgetown, ON, [3]University of Guelph, Guelph, ON, [4]University of Guelph, Ridgetown, ON, [5]Monsanto Canada, Guelph, ON (113)

†Comparing Farmer and University Practices for Controlling Giant Ragweed. JD Bethel*[1], Mark M. Loux[1], Steve Prochaska[2]; [1]The Ohio State University, Columbus, OH, [2]The Ohio State University, Marion, OH (114)

Costs and Benefits of Establishing Alfalfa with Glyphosate Across Seven Production Fields in Wisconsin. Mark J. Renz*; University of Wisconsin Madison, Madison, WI (115)

†Fall Weed Management to Limit SCN Population Build-up. Rodrigo Werle*[1], Mark L. Bernards[2], Loren J. Giesler[1], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL (116)

†Can Soil-Residual Protoporphyrinogen Oxidase (PPO)-Inhibiting Herbicides Influence the Frequency of PPO-Resistant Waterhemp? R. Joseph Wuerffel*, Bryan G. Young, Julie M. Young, Joesph L. Matthews; Southern Illinois University, Carbondale, IL (117)

New Preemergence Residual Weed Management Systems for Glyphosate Tolerant Soybeans to Address Resistance Management. James Whitehead*[1], Dave Feist[2], Gerald Wiley[3], Keith Miller[4], Dave Downing[5], Brian Ahrens[6]; [1]MANA, Oxford, MS, [2]MANA, Fort Collins, CO, [3]Wiley Ag Consulting, Columbus, IN, [4]MANA, Troy, IL, [5]MANA, Raleigh, NC, [6]MANA, Coralville, IA

Preemergence and Postemergence Control of Amaranthus Species with Lactofen Alone and in Combination with V-10206. Trevor M. Dale*[1], Eric J. Ott[2], John A. Pawlak[3], Dawn Refsell[4]; [1]Valent USA Corporation, Plymouth, MN, [2]Valent USA Corporation, Greenfield, IN, [3]Valent USA Corporation, Lansing, MI, [4]Valent USA, Lathrop, MO (119)

†Carrier Volume Influence on the Efficacy of Four Soybean Herbicides. Cody F. Creech*[1], Lowel Sandell[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (141)

Weed Control in Dicamba Tolerant Soybean. Pratap Devkota*[1], William G. Johnson[1], John B. Willis[2]; [1]Purdue University, West Lafayette, IN, [2]Monsanto, Hanson, KY (153)

Weed Management with Roundup Ready®2 Xtend soybean in Iowa. Dean M. Grossnickle*[1], Micheal D. Owen[2], Damian D. Franzenburg[3], James F. Lux[3], Justin M. Pollard[4]; [1]Iowa State University, Gilbert, IA, [2]ISU, Ames, IA, [3]Iowa State University, Ames, IA, [4]The Monsanto Company, St. Louis, MO (154)

Weed Management Recommendations for Roundup Ready® 2 Xtend soybeans. Simone Seifert-Higgins*[1], John B. Willis[2]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto, Hanson, KY (155)

Weed Management in Dicamba Tolerant Crops with Engenia™. Troy D. Klingaman*[1], John Frihauf[2], Steven J. Bowe[3], Terrance M. Cannan[2], Luke L. Bozeman[3]; [1]BASF Corporation, Seymour, IL, [2]BASF Corporation, Raleigh, NC, [3]BASF Corporation, Research Triangle Park, NC (156)

Influence of Nozzle Selection on Drift Potential and Efficacy of Engenia™. Leo D. Charvat*[1], Walter E. Thomas[2], John Frihauf[3], Steven J. Bowe[2], Greg R. Kruger[4]; [1]BASF Corporation, Lincoln, NE, [2]BASF Corporation, Research Triangle Park, NC, [3]BASF Corporation, Raleigh, NC, [4]University of Nebraska-Lincoln, North Platte, NE (157)

Enlist^{TM} Soybean Tolerance to Applications from Emergence to the R2 Growth Stage. Eric F. Scherder*[1], David C. Ruen[2], Jeff M. Ellis[3], Ralph B. Lassiter[4], Hunter Perry[5]; [1]Dow AgroSciences, Huxley, IA, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Smithville, MO, [4]Dow AgroSciences, Little Rock, AR, [5]Dow AgroSciences, Greenville, MS (158)

Weed Control Options in Enlist^{TM} Soybean. Jeff M. Ellis*[1], Ralph B. Lassiter[2], Bradley W. Hopkins[3], Fikru F. Haile[4], Deane K. Zahn[5]; [1]Dow AgroSciences, Smithville, MO, [2]Dow AgroSciences, Little Rock, AR, [3]Dow AgroSciences, Westerville, OH, [4]Dow AgroSciences, Indianapolis, IN, [5]Dow AgroSciences, Lincoln, NE (159)

A New Mesotrione, Glufosinate and Isoxaflutole Tolerant Trait for Soybean Weed Management. Brett R. Miller*[1], Rakesh Jain[2], Brian Erdahl[3], Aron Silverstone[4], Gordon D. Vail[5], Jayla Allen[6], Jon Fischer[7], Sally Van Wert[8]; [1]Syngenta, Minnetonka, MN, [2]Syngenta, Vero Beach, FL, [3]Syngenta, Clinton, IL, [4]Syngenta, Research Triangle Park, NC, [5]Syngenta, Greensboro, NC, [6]Bayer CropScience, Research Triangle Park, NC, [7]Bayer CropScience, Middleton, WI, [8]Bayer CropScience, Monheim, Germany

Weed Management Programs Utilizing Mesotrione in Herbicide Tolerant Soybeans. Ryan D. Lins*[1], Dain Bruns[2], Thomas H. Beckett[3], Gordon D. Vail[3]; [1]Syngenta, Byron, MN, [2]Syngenta, Marysville, OH, [3]Syngenta, Greensboro, NC (161)

University Evaluation of Isoxaflutole Weed Management Programs in HPPD Tolerant Soybean System. Michael L. Weber*[1], Jayla Allen[2]; [1]Bayer CropScience, Indianola, IA, [2]Bayer CropScience, Research Triangle Park, NC (162)

Glyphosate-Resistant Giant Ragweed Control with Future Weed Control Technologies. Kelly A. Barnett*[1], Thomas C. Mueller[2], Lawrence E. Steckel[1]; [1]University of Tennessee, Jackson, TN, [2]University of Tennessee, Knoxville, TN (163)

Equipment and Application Methods

A New Smartphone App for Quick Reference of Spray Quality for Ground Applications. Ryan S. Henry*[1], William E. Bagley[2], Lowel 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 (33)

†Influence Of Nozzle Type And Spray Volume On Herbicide Coverage At Various Heights In The Canopy Of Soybean Grown In 15. Travis Legleiter*, William G. Johnson; Purdue University, West Lafayette, IN (34)

Tank Mixture of Hydrophilic and Lipophilic Herbicides with Adjuvants. Devin A. Wirth*[1], Rich Zollinger[2], Angela J. Kazmierczak[2]; [1]NDSU, Fargo, ND, [2]North Dakota State University, Fargo, ND (35)

Proposed Dicamba Application Requirements for Roundup Ready® Xtend Cropping System. Joe Sandbrink*[1], Jeff N. Travers[1], Christopher D. Kamienski[2], John B. Willis[3]; [1]Monsanto, St. Louis, MO, [2]Monsanto Company, Washington, IL, [3]Monsanto, Hanson, KY (36)

Spray Quality Effects with Glufosinate and Additives. Angela J. Kazmierczak*[1], Rich Zollinger[1], William E. Bagley[2]; [1]North Dakota State University, Fargo, ND, [2]Wilbur-Ellis, San Antonio, TX (37)

Reduction in Drift and Volatility of Enlist^{TM} Duo with Colex-D^{TM} Technology. David E. Hillger*[1], Kuide Qin[2], David M. Simpson[1], Patrick Havens[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Indianapo;is, IN (38)

†Pre and Postemergence Herbicides on Weed Suppression in a Kentucky Bluegrass (*Poa pratensis*) and Perennial Ryegrass (*Lolium perenne*) Systems with a Conventional Sprayer and an Ultra-Low Volume Sprayer. J Connor Ferguson*[1], Roch E. Gaussoin[1], John A. Eastin[2], Matt D. Sousek[3], Greg R. Kruger[4]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kamterter LLC, Waverly, NE, [3]University of Nebraska-Lincoln, Mead, NE, [4]University of Nebraska-Lincoln, North Platte, NE (39)

Weed Control and Crop Response from Nonselective Herbicides Applied with Spray Hood Technology in Corn, Year Two. Damian D. Franzenburg*[1], Micheal D. Owen[2], Dean M. Grossnickle[3], James F. Lux[1]; [1]Iowa State University, Ames, IA, [2]ISU, Ames, IA, [3]Iowa State University, Gilbert, IA (40)

Flow Rates of New Ground Application Nozzles. Annah Geyer*[1], Ryan S. Henry[2], Lowel Sandell[3], William E. Bagley[4], Greg R. Kruger[2]; [1]University of Nebraska Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]Wilbur-Ellis, San Antonio, TX (41)

†Droplet Size Analysis of a Glyphosate Solution as Influenced by Carrier Volume, Nozzle, and Pressure. Cody F. Creech*[1], Annah Geyer[2], Ryan S. Henry[1], Lowel Sandell[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE (42)

†Tolerance of Selected Weed Species to Broadcast Flaming. Strahinja V. Stepanovic*1, Avishek Datta2, Neha Rana3, Stevan Z. Knezevic3; 1University of Nebraska - Lincoln, Lincoln, NE, 2Asian Institute of Technology, Bangkok, Thailand, 3University of Nebraska-Lincoln, Concord, NE (134)

†Effect of Application Carrier Volume on Herbicide Efficacy with Ten Herbicides Using a Conventional Sprayer and an Ultra-Low Volume Sprayer. J Connor Ferguson*[1], Roch E. Gaussoin[1], John A. Eastin[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kamterter LLC, Waverly, NE, [3]University of Nebraska-Lincoln, North Platte, NE (142)

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†Evaluation of Tolerance and Root Quality on Azalea and Hydrangea Treated with Dimethenamid-P and Pendimethalin Alone and in Mixtures. Jose J. Vargas*[1], James Brosnan[2]; [1]The University of Tennessee, Knoxville, TN, [2]University of Tennessee, Knoxville, TN (144)

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†Should Atrazine at Reduced Rates be Applied PRE or POST in Tank-mix Combinations to Improve Giant Ragweed Control in Corn? Ross A. Recker*[1], Vince M. Davis[2]; [1]Univeristy of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI (76)

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†Giant Ragweed Resistance to Glyphosate in Wisconsin. Courtney E. Glettner*[1], Melinda K. Yerka[1], James K. Stute[2], Timothy L. Trower[1], David E. Stoltenberg[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Janesville, WI (79)

Common Sunflower and Giant Ragweed Emergence Profiles in Kansas. Anita Dille*[1], Analiza H. Ramirez[2]; [1]Kansas State University, Manhattan, KS, [2]University of Florida, Lake Alfred, FL (80)

Response of Giant Ragweed Biotypes to Soil Microbial Pathogens. Jessica R. Schafer*[1], Steven G. Hallett[2], William G. Johnson[2]; [1]Purdue Univeristy, West Lafayette, IN, [2]Purdue University, West Lafayette, IN (81)

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Glyphosate Applications Using Different Rates of UAN as a Carrier. Turner J. Dorr*[1], Jeffrey Golus[2], Greg R. Kruger[3], Lowel Sandell[4], Mark L. Bernards[5], Stevan Z. Knezevic[6]; [1]University of Nebraska Lincoln WCREC, North Platte, NE, [2]University of Nebraska, Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]Western Illinois University, Macomb, IL, [6]University of Nebraska-Lincoln, Concord, NE (83)

Nitrogen Rate and the Effect on Western Corn Rootworm Emergence and Damage to Volunteer Corn. Paul T. Marquardt*, Christian Krupke, William G. Johnson; Purdue University, West Lafayette, IN (84)

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†Results from a Two Year Survey of Stem-boring Insects Found in Missouri Waterhemp Populations. Brock S. Waggoner*, Kevin W. Bradley, Wayne C. Bailey; University of Missouri, Columbia, MO (93)

†When is the Best Time for Emergence: Flowering Phenology, Seed Production and Seed Characteristics of Natural Common Waterhemp (*Amaranthus tuberculatus* (Moq) Sauer) Cohorts. Chenxi Wu*[1], Micheal D. Owen[2]; [1]University of Illinois at Champaign-Urbana, Urbana, IL, [2]ISU, Ames, IA (94)

The Effect of Nitrogen Rate on Volunteer Corn Bt Protein Expression. Paul T. Marquardt*, Christian Krupke, William G. Johnson; Purdue University, West Lafayette, IN (95)

†Environmental Triggers of Winter Annual Weed Emergence. Rodrigo Werle*[1], Andrew J. Tyre[1], Mark L. Bernards[2], Timothy J. Arkebauer[1], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL (96)

†Pollen Viability of *Amaranthus* Species In Vitro. Tye C. Shauck*, Reid J. Smeda; University of Missouri, Columbia, MO (97)

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†Presence and Characterization of Glyphosate Resistant Common Waterhemp and Palmer Amaranth in Kansas. Josh A. Putman*; Kansas State Univeresity, Manhattan, KS (99)

†Sensitivity of Glyphosate-Resistant *Amaranthus* to Glyphosate is Altered by Soil Applied Nitrogen. Jon R. Kohrt*, Bryan G. Young, Joesph L. Matthews, Julie M. Young; Southern Illinois University, Carbondale, IL (100)

Interactions Between Glyphosate, *Fusarium* Infection of Waterhemp, and Soil Microorganisms. Kristin K. Rosenbaum*, Lee Miller, Robert Kremer, Kevin W. Bradley; University of Missouri, Columbia, MO (101)

†Emergence and Control of Putative Herbicide-Resistant Waterhemp. Lacy J. Valentine*[1], Greg R. Kruger[2], Lowel Sandell[3], Zac J. Reicher[1], Patrick Tranel[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Illinois, Urbana, IL (102)

†Weed Hosts of *Clavibacter michiganensis* subsp. *nebraskensis*, Causal Agent of Goss's Bacterial Wilt and Leaf Blight. Joseph T. Ikley*, William G. Johnson, Kiersten A. Wise; Purdue University, West Lafayette, IN (103)

Integrated Weed Management using Row Spacing, Cover Crops, and Soybean Varieties. Amanda M. Flipp*[1], Gregg Johnson[2], Jeffrey Gunsolus[3], Donald Wyse[2]; [1]University of Minnesota - Twin Cities, St. Paul, MN, [2]Univeristy of Minnesota, St. Paul, MN, [3]University of Minnesota, St. Paul, MN (104)

†Allelopathy of Sudangrass Cover Crop on Green Foxtail. Jared J. Schmidt*[1], Sam E. Wortman[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Illinois Urbana-Champaign, Urbana, IL (105)

†Competitive Effects of an Invasive Amaranthaceae (*Achyranthes japonica*) on Soybean Compared with *Amaranthus palmeri* and *A. rudis*. Lauren M. Schwartz*[1], Bryan G. Young[1], David J. Gibson[2]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois Univeristy, Carbondale, IL (121)

Root Colonization of Glyphosate-Treated Weed Biotypes by Soil Microbes. Jessica R. Schafer*[1], Steven G. Hallett[2], William G. Johnson[2]; [1]Purdue Univeristy, West Lafayette, IN, [2]Purdue University, West Lafayette, IN (125)

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Symposium Introduction. J Connor Ferguson*; University of Nebraska-Lincoln, Lincoln, NE

Graduate Education in Weed Science – In With The New and Out With the Old?
Philip Westra*; Colorado State University, Fort Collins, CO (147)

Networking or Not Working. Arlene Taich*; Washington Unviersity-St. Louis, St. Louis, MO

Resume/CV and Interview Skills. Carlos Gomez*; Monsanto Company, Chesterfield, MO

Salary Savvy: Negotiation Tips and Tactics. Dallas Ford*; Syngenta, Kansas City, MO

Want to be a Weed Scientist with University or Industry? Amit Jhala*[1], Vince M. Davis[2], Joe Armstrong[3], Lillian C. Magidow[4]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]Dow AgroSciences, Davenport, IA, [4]Winfield Solutions, St. Paul, MN (151)

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Introductory Comments. Scott Flynn*; Dow AgroSciences, Ankeny, IA

Historical View of Introduced Plants that have Become Invasive. William W. Witt*; University of Kentucky, Princeton, KY (194)

Role of *Miscanthus* spp. in the Biofuel Industry and their Potential Invasiveness. Emily Heaton*[1], Allison Snow[2], Miriti Maria[2]; [1]Iowa State University, Ames, IA, [2]Ohio State University, Columbus, OH (195)

The Pros and Cons of Using Native Perennial Grasses for Biofuel Feedstocks. Rob Mitchell*; USDA-ARS, Lincoln, NE

Invasive Trees as an Energy Crop: What Should We Expect? Scott Flynn*[1], Pat Burch[2], Vanelle Peterson[3]; [1]Dow AgroSciences, Ankeny, IA, [2]Dow AgroSciences, Christiansburg, VA, [3]Dow AgroSciences, Mulino, OR (197)

Importing Plants: Permits and Assessments. Michael Brown*; USDA-ARS, Jefferson City, MO

*PRESENTER † STUDENT CONTEST

Abstracts

WHEAT IMPACTS CONTROL OF HORSEWEED (*CONYZA CANADENSIS*) AND GIANT RAGWEED (*AMBROSIA TRIFIDA*). James R. Martin*, Jesse L. Gray, Dorothy L. Call; University of Kentucky, Princeton, KY (1)

Giant ragweed and horseweed are examples of weeds that occur in wheat. As a general rule both species emerge in the spring in Kentucky; however, there are occasions when horseweed may emerge in the fall. While they may sometimes interfere with wheat harvest, the greatest concern is their impact on double-crop soybeans following wheat harvest. Horseweed is especially difficult to control since most populations are tolerant to glyphosate. Studies over the last three growing seasons were conducted to evaluate giant ragweed and horseweed control where wheat is grown as a rotational grain crop. Each weed species was studied in separate experiments. It is important to note that horseweed emergence in these studies occurred in the spring and not in the fall. Wheat was seeded in the fall at two rates and compared to winter fallow plots with no wheat. The high seeding rate was 31 to 38 seeds/ft^2 and the low rate was 17 or 18 seed/ ft^2. During the planting process, the drill units near the outside edges of the plots were blocked in order to create wide skip rows with an open canopy effect similar to that caused by tramlines. Fallow areas were used as a baseline for measuring the impact of wheat on density and plant height of giant ragweed and horseweed. The heights and numbers of giant ragweed and horseweed plants were determined in late May to early June prior to wheat harvest. Wheat significantly limited the numbers of giant ragweed and horseweed plants when compared with the fallow areas in all three growing seasons. The reduction in numbers of giant ragweed plants due to wheat competition ranged from 82 to 92% in 2010; 54 to 79% in 2011; and 86 to 92 % in 2012. When making similar comparisons for horseweed, the reduction in numbers of plants ranged from 95 to 99% in 2010; 83 to 98% in 2011; and 88 to 99% in 2012. In most instances, numbers of giant ragweed and horseweed plants in the low seeding rate were similar to those in the high seeding rate. The head counts near the end of the season indicated tillering of wheat plants in the low seeding rate enabled wheat to compensate and be equally competitive to that for the high seeding rate. The only situation where there was a statistical difference due to seeding rate of wheat was when the high seeding rate limited density of horseweed in the wide rows in 2010. Both giant ragweed and horseweed plants that were able to survive in wheat were numerically shorter compared with those in the fallow areas in all instances. However, the differences were not statistically different for horseweed in both wide and narrow rows in 2010 and for the narrows rows in 2012. The height of giant ragweed and horseweed plants in wheat tended to be slightly smaller in the high seeding rate than in the low seeding rate; however, the differences were small and were often not statistically significant. The numbers of grain heads and yield of the wheat in the high seeding rate were often numerically greater than those in the low rate, but the differences were not statistically significant in most instances, except for wheat yield in the 2011 giant ragweed study. In summary, the vegetative cover that the wheat provided throughout the winter and early spring helped control giant ragweed and horseweed that emerged in the spring. Future research should focus on populations of horseweed that emerge in the fall and doing more in depth studies on row spacing and lower seeding rates.

SPRING WHEAT YIELD AFTER GLYPHOSATE EXPOSURE AT EMERGENCE. Mike J. Moechnig*, Darrell L. Deneke, David A. Vos, Jill K. Alms; South Dakota State University, Brookings, SD (2)

In no-till fields, some crop producers may delay burn-down herbicide applications until after planting but prior to crop emergence to maximize the number of weeds emerged before glyphosate is applied. However, weather conditions may delay herbicide applications creating a situation where the wheat is just beginning to emerge, winter annual and perennial weeds are much larger than the wheat seedlings, and glyphosate has not been applied. In this situation, crop producers may be tempted to apply glyphosate even though wheat seedlings have emerged from the soil surface. Another concern some people have is the effect of potentially high glyphosate concentrations in the soil on wheat growth and yield. To evaluate these concerns, studies were established in east-central South Dakota in 2011 and 2012. In 2011, glyphosate was applied immediately after planting spring wheat or just as the wheat was beginning to emerge from the soil surface. The late glyphosate application did not affect wheat yield. However, an excessive application of 100 kg a.e. ha^{-1} prior to wheat emergence reduced wheat yield by 80%. In 2012, glyphosate was applied immediately after planting but prior to emergence at rates of 0.8, 20, 39, 79, and 118 kg a.e. ha^{-1}. Wheat yield was not affected by glyphosate until rates exceeded 39 kg a.e. ha^{-1}, which is 45 times greater than the standard glyphosate rate. Results from these studies demonstrated that wheat is very tolerant to glyphosate burn-down applications.

WHEAT RESPONSE TO GLYPHOSATE DRIFT OR CONTAMINATION. Andrew N. Fillmore*, Kirk A. Howatt; NDSU, Fargo, ND (3)

Reports of wheat injured by suspected glyphosate drift have increased as the number of acres planted to glyphosate-resistant crops increased. Sprayer tank contamination is another possible cause of glyphosate exposure and injury. Field trials were conducted near Fargo, North Dakota to evaluate the response of wheat to simulated glyphosate drift or sprayer tank contamination. The objectives were to evaluate visual injury and yield reduction to glyphosate rates. Plots were arranged in a randomized complete block design with 4 replications. Treatments included an untreated check, 8.4, 42, 84, 210, 420, 840, and 1260 g ae/ha rates of glyphosate and applications were made during the four-leaf stage and during the flag leaf stage in separate studies. Treatments were visually evaluated for wheat injury and grain yield. Visual injury 7 days after the 840 ae/ha application at the four-leaf stage was greater than 7 days after the 840 ae/ha application at the flag leaf stage. The 420 g ae/ha rate at the four-leaf stage resulted in 67% reduction compared to 42 g ae/ha rate. Yield reduction was observed at 210 g ae/ha of glyphosate when applied at the four-leaf stage and at 84 g ae/ha when applied at flag leaf stage. At the 840 g ae/ha rate, 85% wheat injury was observed 21 days following application and resulted in zero wheat yield when applied at the four-leaf stage.

CONTROL OF HPPD-RESISTANT WATERHEMP IN CORN AND SOYBEAN. Neha Rana*[1], 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 (4)

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 2012 to evaluate the control of HPPD-resistant waterhemp with premergence (PRE), postemergence (POST), and PRE followed by POST applications. PRE applications of flumioxazin+pyroxasulfone and s-metolachlor+atrazine+mesotrione provided 85% control at 62 DAT. Also, flumioxazin in combination with s-metolachlor+atrazine+mesotrione provided 85% control at 38 DAT. Postemergence herbicides including glyphosate, combination of mesotrione+atrazine and glufosinate, synthetic auxins+mesotrione+atrazine, fluthiacet-methyl+mesotrione, carfentrazone-ethyl+2,4-D provided good control 26 DAT. PRE applications of s-metolachlor+atrazine+mesotrione and acetochlor followed by POST applications of synthetic auxins and atrazine provided greater than 90% control 31 days after PRE and POST application. PRE applications of thiencarbozone-methyl+isoxaflutole and atrazine followed by POST applications of synthetic auxins provided 90 and 87% control 31 days after PRE and POST, respectively. For soybeans, PRE applications of pyroxasulfone+saflufenacil, s-metolachlor+metribuzin, combination of chloransulam-methy+sulfentrazone and s-metolachlor+fomesafen, s-metolachlor+metribuzin in combination with chloransulam-methy+sulfentrazone, and flumioxazin+pyroxasulfone provided ≥94% control 26 DAT. PRE applications of s-metolachlor+metribuzin followed by fomesafen+glyphosate, chloransulam-methyl+sulfentrazone combined with s-metolachlor+metribuzin followed by fomesafen+glyphosate provided greater than 98% control 26 and 35 days after PRE and POST application.

CONTROL OF HPPD-RESISTANT WATERHEMP WITH MESOTRIONE AND TANKMIXES APPLIED PREEMERGENCE. Neha Rana*[1], 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 (5)

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 glycine, synthetic auxins, ALS, PSII, PPO, and HPPD-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 to determine the control of HPPD-resistant waterhemp with preemergence 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 1380, 2770, 5540, and 11100 g ai/ha. 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 25 and 14 times the label rate, respectively. These results indicate that HPPD-resistant waterhemp is also resistant to preemergene applications of mesotrione.

ENLIST^{TM} AHEAD. Joe Armstrong*[1], Tami Jones-Jefferson[2], Mark A. Peterson[2], David E. Hillger[2], Jonathan A. Huff[3]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Herrin, IL (6)

Dow AgroSciences is committed to stewardship of the Enlist^{TM} Weed Control System. Innovative research resulted in the development of Colex-D^{TM} Technology which provides reduced 2,4-D volatility and reduced potential for physical drift. Formulation improvement alone will not prevent off-target movement. The applicator's decisions on nozzle selection, equipment setup, weather conditions, and buffer requirements will directly impact any potential for physical drift. Dow AgroSciences' recommended weed resistance management practices requires the use of Enlist Duo^{TM} herbicide (2,4-D choline salt + glyphosate DMA salt) in a weed control system that includes a residual herbicide such as SureStart^{TM} (acetochlor + clopyralid + flumetsulam), Keystone^{TM} (acetochlor + atrazine), or Keystone LA^{TM} (acetochlor + atrazine).

Enlist^{TM} Ahead is a stewardship program developed for the Enlist Weed Control System. Enlist Ahead consists of three foundational pillars: 1) technology advancements in herbicide product, 2) management recommendations and resources, and 3) education, training, and outreach. Enlist Ahead will provide growers and applicators with training and information for proper selection of application equipment, environmental conditions, and setbacks to ensure responsible herbicide application. Enlist Ahead is a benefits-based management resource designed to help growers and applicators succeed while promoting responsible use of the technology.

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AGRONOMIC PERFORMANCE OF ENLIST^{TM} CORN. David M. Simpson*[1], Jim W. Bing[1], Scott C. Ditmarsen[2], Doug J. Spaunhorst[3], Neil A. Spomer[4]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Madison, WI, [3]University of Missouri-Columbia, Columbia, MO, [4]Dow AgroSciences, Brookings, SD (7)

Dow AgroSciences is currently developing Enlist^{TM} corn with anticipated U.S. commercial launch in 2013, subject to regulatory approvals. Enlist corn contains the *aad-1* gene that conveys robust tolerance to 2,4-D. Enlist corn hybrids have a single copy of the *aad-1* gene that is stable over multiple generations with normal Mendelian segregation. The Enlist trait will be combined with SmartStax® traits to provide herbicide tolerance to 2,4-D and glyphosate herbicides along with Bt traits for control of above- and below-ground insect pests. Key to characterization of Enlist corn is to ensure the protein is present and expression level is consistent across hybrids, particularly when stacked with other traits. Characterization of the agronomics and crop tolerance of Enlist corn across environments in multiple genetic backgrounds is needed. Field trials were conducted in 2012 to compare growth, development and yield of Enlist corn following application of Enlist Duo^{TM} herbicide containing 2,4-D + glyphosate. Trials were designed as split plot with the whole plot factors being Enlist Duo at 0, 2185 and 4370 g ae/ha and the sub-plot factor being hybrid genotypes. Applications were made with CO_2 backpack sprayers calibrated to deliver 15 gallons per acre with AIXR nozzles. The first study consisted of 6 hybrids adapted for North America Corn Belt Zone 4. Data were summarized across 15 locations within zone 4 with 2 reps per location. The second study consisted of 12 hybrids adapted for North America Corn Belt Zone 5. Data were summarized across 16 locations within zone 5 with 2 reps per location. The third study consisted of 12 hybrids adapted for North America Corn Belt Zone 7 produced from common AAD-1 inbred. Data were summarized across 16 locations within zone 7 with 2 reps per location. Results show no significant differences in yield with the Enlist corn hybrids between 2,4-D herbicide treated plots and non-treated controls. Studies were conducted to evaluate the level of AAD-1 protein expression across 6 hybrids in maturity zone 4, 12 hybrids in zone 5 and 12 hybrids in zone 7. The results of this study show that AAD-1 protein expression was similar across all hybrids tested.

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THE INFLUENCE OF 2,4-D AND DRIFT REDUCTION TECHNOLOGIES ON THE EFFICACY OF GLYPHOSATE OR GLUFOSINATE ON FALL PANICUM. Lucas A. Harre*, Bryan G. Young, Joesph L. Matthews, Julie M. Young; Southern Illinois University, Carbondale, IL (8)

Postemergence applications in soybean often require an integration of multiple herbicide modes of action for broad spectrum weed control. The development of soybean resistant to postemergence applications of 2,4-D will allow for unique combinations of different herbicide modes of action. Furthermore, the potential to stack 2,4-D tolerant traits with other herbicide tolerant traits, such as tolerance to glyphosate or glufosinate may allow for improved management of broadleaf weeds. However, potential postemergence herbicide interactions from these herbicide combinations may create new challenges for management of grass species. Field and greenhouse research was conducted to identify possible herbicide interactions when tank-mixing either glyphosate or glufosinate with 2,4-D, for the control of various grass species. Field experiments were conducted near Ridgway and Carbondale, Illinois in 2012 to investigate the influence of 2,4-D and application variables on the efficacy of glyphosate and glufosinate for the control of fall panicum. Treatments included glyphosate (0.84 kg ae/ha) and glufosinate (0.45 kg ae/ha) applied alone and in combination with 2,4-D (0.84 kg/ha), when fall panicum reached an average height of 25 to 30 cm. Additional factors evaluated included the addition of ammonium sulfate (2% w/w) and the use of drift reduction technology (drift reduction nozzle; polyacrylamide drift retardant). Greenhouse studies were conducted to evaluate the influence of 2,4-D across the entire response range of glyphosate and glufosinate on fall panicum, giant foxtail, barnyardgrass, and johnsongrass. In field studies, control of fall panicum by either glyphosate or glufosinate alone ranged from 72 to 99% with no reduction in herbicide efficacy from the addition of 2,4-D. However, a reduction in fall panicum control was observed for both glyphosate and glufosinate applications performed with drift reduction technology due to reduced spray coverage. Fall panicum control was not influenced by the addition of AMS. Greenhouse results were consistent with observations from field experiments with no reduction in glyphosate or glufosinate efficacy from the addition of 2,4-D on any of the grass species evaluated. This research suggests that combinations of 2,4-D with glyphosate or glufosinate may not result in reduced control of the grass species evaluated in this research from antagonistic herbicide interactions. Rather, the drift reduction technology that may be used to perform future 2,4-D applications may compromise herbicide efficacy on grass species.

VOLUNTEER SOYBEAN COMPETITION AND CONTROL IN CORN. Jill K. Alms*, David A. Vos, Mike J. Moechnig, Darrell L. Deneke; South Dakota State University, Brookings, SD (9)

Dry weather conditions in the fall can increase the frequency of soybean pod shattering prior to harvest resulting in greater volunteer soybean densities in the following corn crop. Because these volunteer soybeans are resistant to glyphosate, an additional herbicide must be used in Roundup Ready corn to control volunteer soybeans. However, there is little information that defines corn yield loss associated with volunteer soybeans to determine a control threshold. In 2011 and 2012, soybeans were established at densities ranging from 2 – 90 plants m^{-2} in east-central South Dakota. Corn yield loss associated with these soybean densities could be described with a hyperbolic function where corn yield loss (%) = 66*soybean density (plants m^{-2})/(25+soybean density). The maximum corn yield loss was 50%. Additional studies in 2011 and 2012 demonstrated that volunteer soybeans could be effectively controlled with low rates of tembotrione (30 g a.i. ha^{-1}), dicamba (280 g a.e. ha^{-1}), or dicamba (56 g a.e. ha^{-1}) + diflufenzopyr (22 g a.e. ha^{-1}). Each of these treatments may cost approximately $10/ha. Because of the low control cost, only approximately one volunteer soybean plant in 4 m^{-2} may reduce enough corn yield to justify the added cost of controlling volunteer soybeans.

DANDELION COMPETITION IN CORN. David A. Vos*, Jill K. Alms, Mike J. Moechnig, Darrell L. Deneke; South Dakota State University, Brookings, SD (10)

Even though dandelion (*Taraxacum offinale*) may have a relatively short stature, it may be a relatively strong competitor with a tall crop such as corn. A study was conducted in northwestern South Dakota in a no-till field to evaluate corn yield loss associated with dandelion populations. The dandelion density at the study location was approximately 46 dandelions m^{-2}. Different dandelion densities and ground cover was achieved by applying glyphosate at 0, 0.2, 0.4, 0.9, 1.7, and 2.4 kg a.e. ha^{-1} on May 15, which was also the time of corn planting. This resulted in dandelion densities of 46, 38, 35, 19, 5, and 2 dandelions m^{-2}. There was a linear relationship between dandelion densities or ground cover and corn yield loss, which ranged from 0 to 100%. Linear regression analysis indicated that each dandelion plant increased corn yield loss by approximately 2%. Each percent increase in dandelion ground cover, determined in September, increased corn yield loss by approximately one percent. These results demonstrated that dandelion is very competitive with corn and nearly complete control is required to prevent corn yield loss.

TOLERANCE OF SEED CORN INBREDS TO POSTEMERGENCE APPLICATIONS OF RIMSULFURON + MESOTRIONE + ISOXADIFEN-ETHYL OR NICOSULFURON + ISOXADIFEN-ETHYL. Nicholas R. Steppig*[1], Larry H. Hageman[2], Helen A. Flanigan[3], Patrick M. McMullan[4]; [1]DuPont Crop Protection, Rochelle, IL, [2]DuPont Crop Protection, ROCHELLE, IL, [3]DuPont, Greenwood, IN, [4]DuPont Pioneer, Johnston, IA (11)

Applications of sulfonylurea herbicides have proven to be a very effective method of managing weeds in seed production fields. However, in field and greenhouse tests, some seed corn inbreds have shown an injury response to these herbicides. Crop injury, resulting from an herbicide application, is usually due to the plant's inability to metabolize the active ingredient, but the use of safeners has been shown to decrease injury on crops, while still maintaining weed control. Uninjured inbred populations during seed corn production are particularly important to ensure proper pollination nick timing and to maximize yield of critical hybrid seed. A field study was conducted at the DuPont Rochelle, Illinois Midwest Field Research Station to evaluate the effects of spraying a wide range of seed corn inbreds with two safened sulfonylurea herbicides. Twelve seed corn inbreds from DuPont Pioneer® and three additional varieties, for which crop response was previously established, were planted into a conventional tilled, weed free, loam seedbed. Postemergence applications of herbicide were made at the 4-leaf stage. Rimsulfuron + mesotrione + isoxadifen-ethyl was applied at its recommended rate (109 g ai/ha) as well as a double rate (217 g ai/ha). Nicosulfuron + isoxadifen-ethyl was also applied at a 1x (34 g ai/ha) and a 2x (69 g ai/ha) rate. Crop Oil Concentrate (COC) was added to each treatment at a rate of 1% V/V. Visual injury was rated at 7, 14 and 28 days after application using a scale of 0% = no injury and 100% = complete kill. The twelve seed corn inbreds suffered little to no injury from the applications of safened herbicides, even withstanding a 2X rate of herbicide with very limited damage. The three known varieties exhibited injurious effects just as expected. The 'Pioneer Hybrid P0916' showed good tolerance to the treatments, the 'Jubilee' sweet corn hybrid had moderate tolerance and the 'Merit' sweet corn hybrid had no tolerance at all. Results from this field trial would strongly suggest that rimsulfuron + mesotrione + isoxadifen-ethyl (Realm® Q) and nicosulfuron + isoxadifen-ethyl (Accent® Q) are safe for use on these specific DuPont Pioneer® seed corn inbreds.

SURVEY OF GIANT RAGWEED INFESTATION LEVELS IN OHIO SOYBEAN FIELDS. JD Bethel*, Mark M. Loux, Jason T. Parrish; The Ohio State University, Columbus, OH (12)

A survey was conducted to determine spatial distribution of giant ragweed infestations in Ohio soybean fields in late September. A total of 44 and 51 counties were surveyed in 2011 and 2012, respectively. The survey procedure in 2011 was to follow transects across each county, and every 10 miles, assess the infestation level in the next five soybean fields encountered. In 2012, the infestation level was assessed in all soybean fields encountered. The level of giant ragweed infestation was assessed using the following scale: 0 - field free of giant ragweed; 1 – a few giant ragweed plants; 2 - a few patches of plants; 3 – dense infestation. Fields receiving a rating of two or three were considered to be substantially infested with giant ragweed, and a representative seed sample was collected from these fields for use in subsequent assessment of herbicide resistance. In 2011, giant ragweed was absent from 75% of the 823 fields surveyed, and an additional 19% of fields received a rating of one. Giant ragweed infestations were present in approximately 6.6% of the fields and 22 of the counties surveyed in 2011, and were more frequent in west central Ohio. In 2012, giant ragweed was absent from 90% of the 3,993 fields surveyed, and another 8.2% received a rating of one. Fields receiving a rating of two or three accounted for the remaining 2.1%, and these occurred in 34 counties. Results of this survey indicate that giant ragweed is distributed throughout much of Ohio, and occurs in 50 to 70% of Ohio counties with significant soybean production. The level of giant ragweed control obtained by growers appears to vary over years, and could be affected by planting date and rainfall patterns, among other factors.

RESIDUAL CONTROL OF WATERHEMP WITH DICAMBA. Seth T. Logan*[1], Bryan G. Young[2], Sara M. Allen[3]; [1]Monsanto Company, Pinckneyville, IL, [2]Southern Illinois University, Carbondale, IL, [3]Monsanto Company, St. Louis, MO (13)

Waterhemp represents one of the most problematic weed species in soybean production and the prevalence of herbicide-resistant waterhemp populations compounds the difficulty for identifying effective management strategies. The development of dicamba-tolerant soybeans will allow for the integration of an alternative herbicide mode of action for preplant and postemergence applications for improved foliar control of emerged weeds species in soybean production. In addition to foliar herbicide activity dicamba may also contribute towards residual weed control following dicamba applications. Field experiments were established on glyphosate-resistant waterhemp populations in De Soto and Murphysboro, IL to determine if the residual waterhemp control from preemergence applications of flumioxazin plus chlorimuron, acetochlor, and sulfentrazone plus chlorimuron were influenced by the addition of dicamba and 2, 4-D; and to quantify the length of residual waterhemp control from dicamba and an experimental 2,4-D choline formulation. The soil type at both locations was a silt loam with organic matter (OM) of 1.8 to 2.1% and a cation exchange capacity (CEC) ranging from 6 to 12. Herbicides were applied to weed-free, no-till sites with both locations receiving less than 7 cm of rainfall in the six weeks following herbicide application. Under these low rainfall conditions applications of dicamba applied at 0.56 kg ae/ha provided 87 to 98% control of glyphosate-resistant waterhemp at 28 DAT with the experimental 2,4-D choline formulation applied at 0.84 kg ae/ha providing 84 to 91% control. The addition of dicamba (0.56 kg/ha) to acetochlor (1.26 kg/ha) improved residual control of glyphosate-resistant waterhemp by 25% at 56 days after treatment (DAT) compared with acetochlor applied alone at De Soto. Conversely, the addition of an experimental 2,4-D choline formulation plus glyphosate did not enhance residual control of waterhemp when added to acetochlor. This year's results indicate that the addition of either dicamba or an experimental 2,4-D choline formulation with glyphosate to the premix of flumioxazin and chlorimuron reduced emergence of waterhemp through 50 DAT. This research suggests that the residual activity of dicamba for waterhemp control is variable, but has the potential to extend residual waterhemp control when applied alone or in combination with other residual herbicides. Moreover, the influence of dicamba on residual waterhemp control was more prominent than an experimental 2,4-D choline formulation. Future research to further characterize the potential benefits of the soil residual activity of dicamba applications in dicamba-tolerant soybean will be conducted.

PERCEIVED LIKELIHOOD FOR WEEDS TO EVOLVE RESISTANCE TO DICAMBA.

Roberto J. Crespo[1], Mark L. Bernards*[2], Robert Peterson[3]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL, [3]Montana State University, Bozeman, MT (14)

Because the frequency of alleles conferring resistance to a herbicide is very low, it is not practical to determine the absolute risk (based on allele frequency) of a weed becoming resistant to a newly commercialized herbicide through bioassay screening. However, it is preferable to have some estimate of the risk of key weeds evolving resistance to a new herbicide technology prior to its commercialization. With an accurate assessment, stewardship strategies to mitigate high risk behaviors may be enacted, and the commercial utility of the technology might be extended for a greater number of years. We hypothesized that experts familiar with the biology and frequency of common agronomic weeds and the types of selection pressure that may be imposed with a new technology might be able to accurately assess the risk likelihood of species evolving resistance to a new technology. A survey was developed to assess the risk likelihood for 10 weed species common in corn or soybean cropping systems in the western Midwest to develop resistance to dicamba following the commercialization of dicamba-resistant soybean, and potential economic and environmental impacts if resistance did occur. The survey was sent to 50 weed scientists, agronomists and farmers in June 2010, and 25 individuals submitted responses. Three species (common waterhemp, Palmer amaranth and kochia) were perceived to be at moderate to high risk for evolving resistance to dicamba – less than 20% of respondents thought they would be low risk. Three species (horseweed, common lambsquarters and giant ragweed) were perceived to be of moderate risk for evolving resistance to dicamba. Four species (Canada thistle, field bindweed, velvetleaf and prickly lettuce) were perceived to be at low risk. In general, the weeds regarded as being at high-risk for developing resistance were also perceived as having the highest potential economic and environmental impacts if resistance were to develop. Developing data documenting susceptibility to dicamba for the highest risk weeds will enable weed scientists to monitor changes in these species response to dicamba after dicamba-resistant soybean are commercialized. It may be prudent to require farmers who deploy the new technology in fields where high-risk weeds are prevalent to employ additional herbicide-resistance stewardship strategies.

INTEGRATION OF DICAMBA INTO SOYBEAN (*GLYCINE MAX*) PRODUCTION SYSTEMS FOR CONTROL OF GLYPHOSATE-RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*). Reid J. Smeda*[1], Lawrence E. Steckel[2], Simone Siefert-Higgins[3]; [1]University of Missouri, Columbia, MO, [2]University of Tennessee, Jackson, TN, [3]Monsanto, St. Louis, MO (15)

The use of dicamba on tolerant soybeans represents a new technology that can improve management of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*). Crop safety will permit applications at soybean planting and timely use in-crop. Because of the extended period of Palmer amaranth emergence, integration of dicamba with residual herbicide programs are necessary for season-long control. Dicamba-tolerant soybean was planted May 9 near Portageville, MO and May 16 near Jackson, TN in areas containing glyphosate-resistant Palmer amaranth. At planting (PRE) treatments consisted of 0.56 kg ae/ha dicamba or flumioxazin at 0.071 kg ai/ha. Emerging Palmer amaranth seedlings (initial POST) were treated at 5 to 10 cm in height with one of several treatments: dicamba, 0.56 kg/ha + glyphosate, 0.84 kg ae/ha; dicamba + glyphosate + acetochlor, 1.26 kg ai/ha; and dicamba + glyphosate + acetochlor + fomesafen, 0.34 kg ai/ha, with applications at the appropriate time for each at planting treatment. The timing of the POST applications was based upon the effectiveness of the at planting treatment. At 14 days after the initial POST application, dicamba, 0.56 kg/ha + glyphosate, 0.84 kg/ha was applied on select plots that had received an initial POST treatment. This resulted in: two, single-pass programs (both at planting); seven, two-pass programs; and six, three-pass programs. At Portageville and Jackson, no crop phytotoxicity resulted from at planting applications of dicamba; some soybean stunting (~6%) from flumioxazin was noted for Portageville with no injury detected at Jackson. At the time of the initial POST application, control of Palmer amaranth from the at planting treatments averaged 30.6 and 10.8% for dicamba and flumioxazin, respectively; these respective treatments resulted in 95.1 and 57.9% control of Palmer amaranth at Jackson. Lower control at Portageville reflected low rainfall, which was needed for herbicide activation. Between two and three weeks following the initial POST applications, Palmer amaranth control had dropped below 55% for the at planting dicamba and flumioxazin treatments at both locations. For Portageville at three weeks following the initial POST applications, addition of dicamba to the POST, regardless of whether acetochlor, glyphosate, or fomesafen were included, boosted Palmer amaranth control to an average level of 88.2% if dicamba had been used at planting; control averaged 83.9% if flumioxazin had been used at planting. For Jackson at 2 weeks following the initial POST applications, addition of dicamba to the POST boosted Palmer amaranth control to an average level of 95.7% if dicamba had been used at planting; control averaged 70% if flumioxazin had been used at planting. At 2.5 weeks following the sequential POST applications at Portageville, Palmer amaranth control averaged 71 to 74%; where only a single POST application had been made, control averaged 66.7 to 75%. Approximately 2.5 weeks after the sequential POST was applied at Jackson, Palmer amaranth control averaged 96 to 99%; at this same time control ranged from 74 to 93% where only a single POST application had been made. Discrepancies between locations were likely influenced by the extremely dry conditions at Portageville. Overall, season-long control of glyphosate-resistant Palmer amaranth should include both PRE and POST applications. Although the herbicide applied PRE influenced early season Palmer amaranth control, inclusion of dicamba in the POST program was critical for effective management later in the growing season.

DICAMBA CONTRIBUTES RESIDUAL WEED CONTROL TO ROUNDUP READY® 2 XTEND SOYBEAN SYSTEMS. John B. Willis*[1], Christopher D. Kamienski[2], Mayank S. Malik[3], Simone Siefert-Higgins[4]; [1]Monsanto, Hanson, KY, [2]Monsanto Company, Washington, IL, [3]Monsanto, Lincoln, NE, [4]Monsanto, St. Louis, MO (16)

Roundup Ready® 2 Xtend soybeans (pending regulatory approval) will offer herbicide tolerance to glyphosate and dicamba. Dicamba has been widely used for the past 45 years to control broadleaf weeds in different cropping systems. Dicamba provides a new mode of action in soybeans to manage resistant and hard to control weeds preemergence, preplant, and postemergence. One added benefit of using dicamba is the residual control it can provide. Bare-ground field experiments were conducted at 20 locations across the midwest to evaluate the length of residual control of dicamba applied alone and in combination with other residual herbicides. Treatments were applied to a freshly prepared seed bed with no weeds emerged at the time of application, and plots remained without a crop for the duration of the trials. Experimental design was randomized complete block with 3 or 4 replications. Herbicide treatments included dicamba at 0.56 kg ae/ha and 1.12 kg ae/ha, 2,4-D at 1.12 kg ae/ha, both alone and applied in tank mixtures with acetochlor at 1.25 kg ai/ha, flumioxazin plus chlorimuron-ethyl (Valor XLT) at 0.0846 kg ai/ha, sulfentrazone plus chlorimuron-ethyl (Authority XL) at 0.19 kg ai/ha, and flumioxazin plus pyroxasulfone (Fierce) at 0.160 kg ai/ha. The tank mix partners were also applied alone for comparison. Weed control evaluations were taken by species up to 42 days after treatment (DAT). Dicamba at 1.12 kg ae/ha controlled velvetleaf (*Abutilon theophrasti*) 83% at 35 DAT, whereas 2,4-D provided 53% control at the same rate. Preemergence control of waterhemp (*Amaranthus tuberculatus syn. rudis*) and Palmer amaranth (*Amaranthus palmeri*) was 87% and 78%, respectively, with dicamba at 35 DAT, while 2,4-D provided 74% and 57% control, respectively, of these weeds at 35 DAT. Similarly, common lambsquarters (*Chenopodium album*) control with 2,4-D was 31%, while dicamba provided 86% at 35 DAT. Residual products included in this study applied alone provided higher levels of control than dicamba alone in most weed species, but tank mixing dicamba and residual products improved weed control across all species. Weed control from residual herbicides included in this study alone ranged from 56% to 85% at 35 DAT. Tank mixing dicamba at 1.12 kg ae/ha with acetochlor, flumioxazin plus chlorimuron-ethyl, sulfentrazone plus chlorimuron-ethyl, and flumioxazin plus pyroxasulfone provided 79% to 95% Palmer amaranth and waterhemp control when evaluated at 35 DAT. Common lambsquarters and velvetleaf control with dicamba tank mixes ranged from 84% to 94%, 35 DAT. These results indicate that dicamba applied in combination with other residual herbicides can provide increased levels of residual control up to 35- 42 DAT. The addition of dicamba to burndown and in-season weed management in Roundup Ready® 2 Xtend soybean can provide more consistent weed control and can provide a more sustainable solution to management of glyphosate-resistant and hard to control weeds.

WEED CONTROL WITH BAS18322H IN CORN AND DICAMBA-TOLERANT SOYBEAN. Jon E. Scott*[1], Leo D. Charvat[2], Neha Rana[1], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE (17)

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 producers another option for weed control. Field studies were conducted in 2011 and 2012 in corn and soybean cropping system with dicamba applied pre and postemergent in the new BAS18322H formulation designed to reduce off target movement. Dicamba applied alone at preemergence rates of 560 to 2240 g ai/ha failed to provide good control (63 to 80%) of velvetleaf at 45 DAT. Lack of rainfall after application also contributed to these results. However, BAS18322H applied preemergence at 420 g ai/ha in soybean provided excellent control of giant ragweed at 30 DAT. When applied postemergence BAS18322H alone or in a tankmix at 420 g ai/ha provided 92 to 100% control of giant ragweed. Additionally, control of waterhemp and redroot pigweed ranged from 70 to 95% and 40 to 90%, respectively, at 45 and 60 DAT. These results indicate potential use of BAS18322H to control glyphosate resistant giant ragweed; however care should be taken to avoid use as a single treatment or dicamba/glyphosate combination as additional tankmix partners may be needed to control other broadleaf weeds such as velvetleaf and waterhemp. Dicamba should be used in conjunction with residual herbicides to control broadleaf species in a Best Management Practice Program.

INTEGRATED MANAGEMENT OF DIFFICULT TO CONTROL WEEDS IN DICAMBA TOLERANT SOYBEANS IN NEBRASKA. Jeffrey Golus*[1], Ryan S. Henry[2], Lowel Sandell[3], Mayank S. Malik[4], Simone Siefert-Higgins[5], Greg R. Kruger[2]; [1]University of Nebraska, Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]Monsanto, Lincoln, NE, [5]Monsanto, St. Louis, MO (18)

Glyphosate-resistant weeds have become increasingly problematic in Nebraska in recent years. Glyphosate-resistant horseweed was first reported in Nebraska in 2006. Since then, glyphosate-resistant kochia and glyphosate-resistant giant ragweed have also been reported. Due to the observation of glyphosate-resistant weeds in neighboring states, there is growing concern about the potential for glyphosate-resistant Amaranthus sp. (i.e. waterhemp and Palmer amaranth) to move into the state as well. Nebraska has many no-till acres and producers look to manage glyphosate-resistant weeds and other weeds which are difficult to control with glyphosate with other herbicides, particularly other postemergence herbicides. Many producers are eager to have more postemergence herbicides with highly effective control of herbicide-resistant weeds. Studies were conducted in Nebraska to determine the efficacy of postemergence applications of dicamba in dicamba-tolerant soybean systems. Combinations of preemergence and postemergence herbicide applications were tested. In general, the dicamba-tolerant soybean systems with preemergence residual herbicides followed by in-season applications of dicamba plus glyphosate had the greatest efficacy on glyphosate-resistant broadleaf weeds. Kochia in particular was controlled well when residual based herbicides were followed by in-season applications of dicamba plus glyphosate. In-season applications of dicamba plus glyphosate had excellent control of glyphosate-resistant giant ragweed, but it should be noted that timing was critical. In the opinion of the authors, dicamba-tolerant soybeans will give producers another in-season tool to manage glyphosate-resistant weeds as well as other difficult-to-control weeds, but the system needs to be sustained by making sure that this product is used in combination with other herbicide modes-of-action, tank mixtures, and timely applications on small weeds.

PERFORMANCE OF COMMERCIAL TRACK GLYPHOSATE AND DICAMBA TOLERANT SOYBEAN VARIETIES.

Cindy L. Arnevik*[1], Mindy Devries[2], Mark Lubbers[3], Joe Cordes[4]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto Company, Huxley, IA, [3]Monsanto Company, Wichita, KS, [4]Monsanto Company, Jerseyville, IL (19)

Roundup Ready ® 2 Xtend soybeans are breeding stack of Roundup Ready 2 Yield® glyphosate tolerant soybeans with a dicamba tolerant transgenic soybean event currently under regulatory review. In 2012 trials were established in Kansas and Illinois to demonstrate the tolerance of four soybean varieties that had been advanced by the Monsanto breeding organization as potential commercial varieties at launch. The study demonstrated that these lines have commercial tolerance to application rates expected to be recommended at launch as well as a 2X safety margin. These findings are consistent with the data generated in previous years on the transformation event from which the test materials were derived.

WEED CONTROL IN SOYBEAN AS INFLUENCED BY RESIDUAL HERBICIDE USE AND GLYPHOSATE APPLICATION TIMING FOLLOWING DIFFERENT PLANTING DATES.

Ryan P. DeWerff*, Shawn P. Conley, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (20)

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 influence the crops' ability to compete with weeds, and there are limited research reports investigating this relationship. We hypothesized the benefit of early-season weed control with preemergence (PRE) residual herbicides would diminish with later soybean planting dates. To test this hypothesis, a field experiment was conducted in 2012 at the University of Wisconsin Arlington Research Station to determine weed control and soybean yield as influenced by residual herbicide use and postemergence (POST) glyphosate application timing following three different planting dates. Plots were planted on April 24, May 10, and June 4 to represent early, mid, and late planting dates respectively. A PRE application of 0.26 kg a.i. sulfentrazone plus 0.03 kg a.i. cloransulam-methyl was applied to half of the plots following each planting date. Glyphosate at 0.77 kg a.e. 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. 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).* Weed densities prior to the POST application were 16 m^{-2}, 16 m^{-2}, and 2 m^{-2} for the early, mid, and late planting dates, respectively, averaged across plots where the residual was applied PRE. In the absence of the PRE residual application, weed densities averaged 67 m^{-2}, 31 m^{-2}, and 3 m^{-2} for the early, mid, and late planting dates, respectively. Soybean yield was 3363 kg , 3795 kg , and 3637 kg for the early, mid, and late planting dates, respectively, averaged across plots where the residual was applied PRE. Yield in the absence of a PRE residual application was 2532 kg , 3620 kg , and 3642 kg for the early, mid, and late planting dates, respectively. Thus, the use of a PRE residual herbicide increased yield by 33% and 5% for the early and mid planting dates, respectively, and the difference was only significant at the early planting date ($P = 0.0001$). We conclude early results support our hypothesis that the value of using a PRE residual herbicide diminished with later planting dates; however, we will continue to investigate by repeating this experiment in 2013.

EFFECTIVENESS OF COMBINATIONS OF GLYPHOSATE AND GLUFOSINATE ON GLYPHOSATE-RESISTANT HORSEWEED.

Tyler Johnson*, Mark M. Loux, Anthony Dobbels; The Ohio State University, Columbus, OH (22)

A field study was conducted to determine the effectiveness of various preplant soybean herbicides for control of emerged glyphosate-resistant horseweed, including combinations of glyphosate and glufosinate. Experiments were conducted in 2012 in four different situations: 1) population A – not previously treated, tilled or mowed – 10 to 15 cm tall; 2) population A – previously treated with glyphosate – 10 to 30 cm tall; 3) population B – previously mowed in mid-summer and regrowth to a height of 10 cm; 4) population C – previously tilled and infested with plants surviving tillage and plants that emerged after tillage (5 to 15 cm tall). In addition to visual evaluation of control at 21 days after treatment (DAT), the mortality of 10 plants per plot was measured. Control of horseweed did not exceed 85% in any experiment, and was lowest in situation four where plants had survived tillage and were growing under extremely dry conditions. Trends in the results included the following: 1) the combination of glyphosate and glufosinate was not more effective than glufosinate alone; 2) most effective control generally occurred with the three-way combination of glyphosate, glufosinate and either 2,4-D or safulfenacil; and 3) where glufosinate was applied alone or in combinations, 450 g/ha was more effective than 220 g/ha.

EFFECT OF EARLY-SEASON WEED CONTROL ON NUTRIENT COMPETITION AND YIELD IN SOYBEAN.

Nick T. Harre*[1], Bryan G. Young[1], Scott Cully[2], Brett R. Miller[3], Mark Kitt[4]; [1]Southern Illinois University, Carbondale, IL, [2]Syngenta Crop Protection, Marion, IL, [3]Syngenta, Minnetonka, MN, [4]Syngenta Crop Protection, Minnetonka, MN (23)

The popularity of growers using only postemergence herbicides for weed management in soybean was enabled by the commercialization of glyphosate-resistant soybean since glyphosate provided robust weed control with little risk for crop injury. Consequently, the utilization of soil residual herbicides decreased dramatically and, arguably, the potential risk for soybean yield loss from early-season weed competition increased. Furthermore, the evolution and frequency of glyphosate-resistant weed biotypes necessitates a more sound approach to soybean weed management. Although the recent trend of once again employing soil residual herbicides has been dictated in large part by herbicide resistance management, the commercial interest in high-yield soybean production justifies further characterization of the benefits for early-season weed management. Field experiments were initiated to study the influence of early-season weed management strategies and the effect of weed competition duration on the nutrient content in soybean and weeds, along with determining the impact on soybean grain yield. Weed removal with a POST application of glyphosate was performed when weeds reached 10, 20, 30, or 45 cm in height as well as a weed-free treatment utilizing soil residual herbicides. Two standard herbicide management strategies were also evaluated for comparison: 1) flumioxazin PRE followed by glyphosate POST and 2) two POST glyphosate applications applied sequentially. Significant soybean grain yield reductions as influenced by lack of early-season weed management were observed at one of four sites. Nitrogen and phosphorus accumulation in weeds reduced the concentration of these nutrients in the soybean plant at multiple locations. Weed competition with soybean also reduced the concentration of the micronutrients calcium, sulfur, iron, manganese, boron, and copper in soybean. Therefore, sound strategies for early-season weed management provide agronomic benefits beyond herbicide resistance management as it has specific implications on soybean nutrient competition and grain yield.

EFFICACY OF PREEMERGENCE VERSUS POSTEMERGENCE HERBICIDES ON GLYPHOSATE-RESISTANT HORSEWEED (*CONYZA CANADENSIS*) IN SOYBEAN (*GLYCINE MAX*).

Cody D. Cornelius*, Reid J. Smeda, Carey F. Page; University of Missouri, Columbia, MO (24)

Since the initial report of glyphosate-resistant horseweed (*Conyza canadensis*) in Delaware in 2001, resistance in this species has been reported in 21 states throughout the soybean production area in the U.S. Recent observations suggest that seedlings emerge in the fall as well as the spring, complicating the design of appropriate management systems. A field study was established near Novelty, MO in 2011 to examine the utility of fall and spring residual and non-residual herbicide programs for optimum management of horseweed. The timing of herbicide treatments included: fall (November 15); 30 day pre-plant (March 28, 2012); at soybean planting (May 17); and POST on 10 to 16 cm horseweed (June 20). Fall programs included: flumioxazin + chlorimuron + tribenuron-methyl; sulfentrazone + chlorimuron + tribenuron-methyl; acetochlor + tribenuron-methyl; and sulfentrazone + cloransulam + tribenuron-methyl; sulfentrazone + metribuzin; or 2,4-D. The 30 day pre-plant treatments included the same residual programs applied in the fall, but also included 2,4-D, dicamba, or glyphosate. All fall and 30 day pre-plant treatments included glyphosate. At planting treatments included saflufenacil and were applied following all fall programs except 2,4-D alone; saflufenacil was also applied alone. POST applications of glyphosate were used for all residual treatments. A glyphosate + cloransulam and untreated control were also included. Visual control (0 = no control and 100 = plant death) of horseweed was recorded for all treatments at soybean planting (184 days after the fall applications), at the POST application (34 days after planting), as well as 21 and 41 days after the POST application. Germination of horseweed in the experimental area was not observed until early spring and continued through June. At soybean planting, horseweed control in the fall residual compared to 30 day pre-plant residual treatments averaged 76 and 99%, respectively suggesting the need to have effective levels of herbicide during the time of horseweed establishment. Inclusion of a growth regulator such as 2,4-D or dicamba at the 30 day pre-plant timing improved horseweed control over glyphosate alone by 19 to 40%; dicamba improved horseweed control by 27% versus 2,4-D. Use of glyphosate plus a growth regulator (non-residual) versus a residual program timed 30 day pre-plant resulted in a similar level of horseweed control at the time of planting (90 versus 99%), but differences in control were noted at the POST timing (93% for residual versus 50% for non-residual) and were even greater 5 weeks after the POST application (71% for residual versus 16% for non-residual). Although a number of herbicides and timings can be effective for management of horseweed, it is important that multiple applications are utilized.

A RAPID, HIGH-THROUGHPUT MOLECULAR ASSAY FOR THE ROBUST GENOTYPIC DETERMINATION OF WATERHEMP RESISTANT TO PROTOPORPHYRINOGEN OXIDASE (PPO)-INHIBITING HERBICIDES.

R. Joseph Wuerffel*[1], Bryan G. Young[1], David A. Lightfoot[1], Patrick Tranel[2], Ahmad M. Fakhoury[1]; [1]Southern Illinois University, Carbondale, IL, [2]University of Illinois, Urbana, IL (25)

The evolution of herbicide-resistant weeds has considerably influenced the focus of weed science research as scientists pursue an improved understanding of the causal mechanisms of herbicide resistance. Recent advances in molecular genetics have allowed weed scientists to utilize innovative techniques for describing herbicide resistance at the molecular level. In weed science, molecular assays are often used as detection tools to identify herbicide-resistant individuals within a population. One particular weed species, common waterhemp (*Amaranthus tuberculatus*), has developed resistance to multiple herbicidal modes of action, including protoporphyrinogen oxidase (PPO)-inhibitors. Waterhemp resistance to PPO-inhibiting herbicides is a consequent of a target-site mutation in *PPX2L* (the autosomally-inherited gene coding for the PPO enzyme) via a codon deletion. The phenotypic response of resistant and susceptible waterhemp to PPO-inhibiting herbicides is highly dependent on environmental conditions; therefore, molecular diagnosis of resistant individuals is often more reliable for identifying resistant populations. Several molecular techniques are available for genotyping *PPX2L*, such as a simple allele-specific PCR (polymerase chain reaction) and gene sequencing; however, these techniques lack the specificity for detection of heterozygous individuals or they are cost prohibitive when testing large sample sets, respectively. Real-time PCR (RT-PCR) is a technique often used for detection and quantification of polymorphisms. A specific type of RT-PCR, the TaqMan® technique, utilizes fluorescent, allele-specific probes for a robust allelic discrimination at a given locus. Additionally, the high sensitivity of TaqMan® assays are generally sufficient to detect low-allelic frequencies within pooled samples. As herbicide-resistant weeds become an increasingly prevalent problem, it is vital to understand the ecological implications of these evolved resistance mechanisms. Therefore, a robust, high-throughput TaqMan® assay for the allelic determination of *PPX2L* is currently being developed for the detection of homozygous-resistant/-susceptible and heterozygous individuals, with anticipation of low-frequency allele detection in pooled samples. Once optimized, weed science researchers will have another tool to better understand allelic frequencies of *PPX2L* within natural field populations. Furthermore, there is the potential to adapt this technique to increase polymorphism detection efficiency and to improve the understanding of population dynamics in other herbicide-resistances.

EFFECTS OF FLAMING AND CULTIVATION ON WEED CONTROL AND YIELD IN ORGANIC SOYBEANS INFLUENCED BY MANURE APPLICATION.

Strahinja V. Stepanovic*[1], Avishek Datta[2], Neha Rana[3], Brian D. Neilson[4], Chris Bruening[1], George Gogos[1], Stevan Z. Knezevic[3]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska-Lincoln, Lincoln, NE (26)

Propane flaming in combination with cultivation could be a potential alternative tool for weed control in organic soybean production. Field studies were conducted at the Haskell Agricultural Laboratory in 2010, 2011 and 2012 to determine the level of weed control and crop response to flaming and cultivation utilizing flaming equipment developed at the UNL. The treatments included: weed-free control, weedy season-long and different combinations of banded flaming (intra-row), broadcast flaming and mechanical cultivation (inter-row). Treatments were applied at the VC (unfolded cotyledon) and/or V4 (fourth trifoliate) growth stages. Propane doses were 20 and 45 kg/ha for the banded and broadcast flaming treatments, respectively. Visual ratings of crop injury and weed control level were evaluated at 1, 7, 14 and 28 days after treatment (DAT). Yield components and grain yield data were also collected. The combination of mechanical cultivation and banded flaming applied at both the VC and V4 stages exhibited the highest level of weed control (>80%) at 28 DAT. Cultivation alone at VC and V4 stages, provided only 50% weed control. No crop injury was observed at 28 DAT, except at full flaming conducted twice, where 35% visual crop injury was observed. Banded flaming in combination with cultivation at the VC and V4 stages had the highest average yield, only 10% less than weed-free control and significantly higher than the rest of the treatments. Cultivation combined with flaming has a potential to effectively control the weeds in organic soybean production.

GLYPHOSATE-RESISTANT GIANT RAGWEED IN ONTARIO. Nader Soltani*[1], Joanna Follings[2], Mark Lawton[3], François Tardif[2], Darren E. Robinson[4], Peter Sikkema[5]; [1]University of Guelph Ridgetown Campus, Ridgetown, ON, [2]University of Guelph, Guelph, ON, [3]Monsanto Canada, Guelph, ON, [4]University of Guelph, Ridgetown, ON, [5]University of Guelph - Ridgetown Campus, Ridgetown, ON (27)

Giant ragweed (*Ambrosia trifida*) is an extremely competitive weed and is becoming an increasing problem for soybean growers in southwestern Ontario. In 2008, a giant ragweed biotype from a single farm near Windsor, ON was confirmed to be the first glyphosate-resistant (GR) weed in Canada. Surveys conducted in 2009, 2010, and 2011 have confirmed 18, 29, and 23 additional sites in southwestern Ontario with GR giant ragweed, respectively. Based on these surveys a total of 71 fields in Essex, Kent, Lambton, Middlesex, and Lennox & Addington counties are infested with GR giant ragweed. Over time the number of locations is increasing and GR giant ragweed is found over a wider geographical area. Field trials were established at various sites with GR giant ragweed during the 2010-2012 to evaluate preplant or postemergence herbicides in soybean. The recommended field rate (900 g ae/ha) provided only 44% control, while some giant ragweed plants were able to survive glyphosate applied at 43,200 g ae/ha or 48 times the recommended field rate. Field studies indicated that glyphosate plus 2,4-D (97%) or amitrole (93%) provide the best control of GR giant ragweed while linuron (83%) or cloransulam-methyl (82%) were also effective. Glyphosate alone or tankmixed with carfentrazone, glufosinate, paraquat, saflufenacil, saflufenacil/dimethenamid-p, chlorimuron, flumioxazin, chlorimuron+flumioxazin, metribuzin, flumetsulam, imazethapyr, clomazone, flumioxazin, flumioxazin+chlorimuron or pyroxasulfone+flumioxazin provided poor/inconsistent control of GR giant ragweed in soybean. Among the postemergence herbicide tankmixes evaluated, cloransulam-methyl (74%) provided marginal control of GR giant ragweed in soybean. Glyphosate alone or in combination with acifluorfen, fomesafen, bentazon, thifensulfuron, chlorimuron, imazethapyr, imazethapyr+bentazon or glyphosate/fomesafen applied POST provided poor/inconsistent control of GR giant ragweed in soybean. Use of dicamba with dicamba-tolerant soybeans was effective for the control of GR giant ragweed depending on rate and timing. Sequential applications of glyphosate plus dicamba provided 100% control.

SELECTIVITY OF AN&NBSP;HPPD-TOLERANT SOYBEAN EVENT. Jayla Allen[1], John Hinz*[2], Michael L. Weber[3]; [1]Bayer CropScience, Research Triangle Park, NC, [2]Bayer CropScience, Story City, IA, [3]Bayer CropScience, Indianola, IA (28)

MS Technologies and Bayer CropScience are codeveloping a soybean event tolerant to glyphosate and p-hydroxyphenyl pyruvate dioxyegenase (HPPD) inhibiting herbicides. Soybeans containing this soybean event were also stacked with a Bayer CropScience glufosinate tolerant (LibertyLink) soybean event to generate soybean plants tolerant to all three herbicides. Tolerance to glyphosate and glufosinate are similar to commercially available varieties. These lines have commercially acceptable tolerance to pre-emergence applied isoxaflutole and mesotrione.

EFFICACY OF PRE AND POST HERBICIDES FOR CONTROLLING MULTIPLE-RESISTANT PALMER AMARANTH IN MICHIGAN. David Powell*, Christy Sprague; Michigan State University, East Lansing, MI (29)

Field experiments were conducted in 2011 and 2012 on a grower's field in Southwest Michigan to evaluate preemergence (PRE) and postemergence (POST) herbicide options for control of glyphosate- and ALS-resistant Palmer amaranth. One experiment evaluated PRE herbicide options; while the second experiment evaluated POST herbicide options applied at multiple rates and application timings. Initially over 20 PRE herbicide treatments were evaluated for Palmer amaranth control in 2011, these treatments were further refined in 2012 based on observations from the previous year. The PRE herbicide treatments that provided the greatest control of Palmer amaranth contained flumioxazin. More consistent and the greatest control with flumioxazin was when pyroxasulfone was added (80-90%). However, this treatment also resulted in the greatest soybean injury and none of these treatments provided season-long control. Over the two years, control of Palmer amaranth was less consistent with the other herbicide treatments. For example, with sulfentrazone Palmer amaranth control was 25% in 2011 and 78% in 2012, 30 days after treatment (DAT). None of the ALS-inhibiting herbicide based treatments were effective at controlling Palmer amaranth in 2011, so they were removed from the 2012 experiment. Of the PRE herbicide treatments evaluated in both years, applications of metribuzin, pendamethalin, *s*-metolachlor, pyroxasulfone, and *s*-metolachlor plus fomesafen all resulted in less than 60% control, 30 DAT. The second experiment evaluated control of glyphosate-/ALS-resistant Palmer amaranth from fomesafen at 0.26 kg ha^{-1} and lactofen at 0.14 and 0.22 kg ha^{-1} applied to 8- and 18-cm tall plants. In 2012 glufosinate at 0.45, 0.60, and 0.74 kg ha^{-1} was also evaluated. Over the two years, fomesafen was more consistent at controlling glyphosate-/ALS-resistant Palmer amaranth than lactofen. Additionally, the time of application was extremely critical. When Palmer amaranth was 18-cm tall, control with fomesafen was less than 60%. However, control with fomesafen was greater than 75% when Palmer amaranth was 8-cm tall. Glufosinate generally provided the greatest control of glyphosate-/ALS-resistant Palmer amaranth. Control was greater than 80% when glufosinate was applied to 8-cm tall Palmer amaranth at 0.60 and 0.74 kg ha^{-1} and control of Palmer amaranth was 74% when glufosinate was applied at 0.74 kg ha^{-1} at the 18-cm timing. This research indicated no PRE or POST herbicide treatment alone will completely control glyphosate-/ALS-resistant Palmer amaranth. To mitigate infestations of multiple-resistant Palmer amaranth the use of PRE followed by POST herbicide programs is necessary. Additional research is needed to develop herbicide programs that will control Palmer amaranth while delaying the further evolution of herbicide-resistance.

GLYPHOSATE-RESISTANT CANADA FLEABANE IN ONTARIO.

Nader Soltani*[1], Holly P. Byker[2], Mark Lawton[3], Darren E. Robinson[4], François Tardif[5], Peter Sikkema[6]; [1]University of Guelph Ridgetown Campus, Ridgetown, ON, [2]University of Guelph, Ridgetown Campus, Ridgetown, ON, [3]Monsanto Canada, Guelph, ON, [4]University of Guelph, Ridgetown, ON, [5]University of Guelph, Guelph, ON, [6]University of Guelph - Ridgetown Campus, Ridgetown, ON (30)

Seed collected in the fall of 2010 confirmed glyphosate resistant (GR) Canada fleabane (*Conyza canadensis*) in 8 fields in Essex County in southwestern Ontario, Canada. A survey conducted in 2011 identified 76 additional fields in Essex, Kent, Elgin, Lambton, and Niagara counties in southern Ontario with GR Canada fleabane. Field studies were conducted during summer of 2011 and 2012 to determine a) the biologically effective rate of glyphosate, b) the efficacy of herbicide tankmixes applied preplant, c) the efficacy of herbicides applied preemergence for full season residual weed control, and d) the efficacy of postemergence herbicide tankmixes in soybean for the control of GR Canada fleabane in soybean. GR Canada fleabane survived glyphosate rates as high as 43,200 g ai/ha which is 48 times the manufacturer's recommended rate. Among the preplant herbicide tankmixes evaluated, saflufenacil (97%) and saflufenacil/dimethenamid-p (96%) provided the best control while amitrole (87%) and 2,4-D (86%) were also effective in controlling GR Canada fleabane. Glyphosate alone or tankmixed with carfentrazone, glufosinate, paraquat, cloransulam-methyl, chlorimuron, flumioxazin, chlorimuron+flumioxazin provided poor/inconsistent control of GR Canada fleabane in soybean. Among the preemergence residual herbicide treatments evaluated, metribuzin (99%) and flumetsulam (94%) provided the best control while cloransulam-methyl (89%) was also effective in control GR resistant Canada fleabane. Glyphosate alone or in combination with chlorimuron, linuron, imazethapyr, clomazone, flumioxazin, flumioxazin+chlorimuron or pyroxasulfone+flumioxazin provided poor/inconsistent control of GR Canada fleabane in soybean. Among the postemergence herbicide tankmixes evaluated, cloransulam-methyl (51%) and chlorimuron (45%) provided marginal control of GR Canada fleabane in soybean. Glyphosate alone or in combination with acifluorfen, fomesafen, bentazon, thifensulfuron, imazethapyr, imazethapyr+bentazon or glyphosate/fomesafen applied POST provided poor/inconsistent control of GR Canada fleabane in soybean. In dicamba tolerant soybean, dicamba provided good to excellent control of GR Canada fleabane depending on rate.

SOYBEAN RESPONSE AND YIELD IMPLICATIONS OF POSTEMERGENCE TANK-MIXTURES IN GLYPHOSATE-RESISTANT SOYBEAN.

Theresa A. Reinhardt*[1], Bryan G. Young[1], Joesph L. Matthews[1], Julie M. Young[1], Douglas J. Maxwell[2], Aaron G. Hager[2], Mark L. Bernards[3]; [1]Southern Illinois University, Carbondale, IL, [2]University of Illinois, Urbana, IL, [3]Western Illinois University, Macomb, IL (31)

The prevalence of glyphosate-resistant weeds necessitates the integration of alternative herbicide modes of action that can provide effective weed management. In soybean the combination of glyphosate with PPO-inhibiting herbicides at progressively increasing application rates for postemergence weed control may give rise to the potential soybean injury and yield loss associated with these applications. Therefore, field experiments were conducted to investigate the influence of glyphosate tank-mix partner, herbicide rate, application timing, and planting date on soybean injury and yield. Field trials were conducted at Belleville and Urbana, IL in 2011 and 2012 with targeted soybean planting dates of May 1 (early) and June 15 (late). Herbicide treatments included glyphosate at 860 and 1720 g ae/ha alone and in combination with lactofen at 105 and 211 g ai/ha, fomesafen at 263 and 420 g ai/ha, or fluthiacet at 4.8 and 7.2 g ai/ha, applied at three different timings based on soybean growth stage: V2-V3, V5-V6, and R2. The response of soybean to glyphosate tank-mixtures varied by location with visual injury ranging from 0 to 50% from herbicide applications. At Belleville, soybean yield was influenced by the interaction between planting date, tank-mix partner, and application timing. Soybean yield was reduced by up to 16% (548 kg/ha) with the addition of all three PPO-inhibiting herbicides at various application timings in the late-planted soybean, but only by lactofen applied at R2 in early-planted soybean. Soybean yield at Urbana was influenced by tank-mix partner and tank-mix partner rate but not by application timing or glyphosate rate. Combinations of lactofen at 211 g/ha with glyphosate reduced soybean yield by 201 kg/ha compared with untreated soybean. Yield was not reduced by any other herbicide combination. Combining full rates of glyphosate and postemergence PPO-inhibiting herbicides may be necessary for weed management, yet should be carefully implemented into sound weed management strategies to prevent unnecessary soybean yield loss resulting from herbicide injury. This is especially important in short-season soybeans and with herbicide applications performed during reproductive soybean growth.

PREEMERGENCE PALMER AMARANTH CONTROL WITH FIERCE^{TM} HERBICIDE IN US SOYBEAN PRODUCTION.

Eric J. Ott*[1], Dawn Refsell[2], Trevor M. Dale[3], Gary W. Kirfman[4], John A. Pawlak[5]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA, Lathrop, MO, [3]Valent USA Corporation, Plymouth, MN, [4]Valent USA Corporation, Ada, MI, [5]Valent USA Corporation, Lansing, MI (32)

Weed resistance to glyphosate continues to expand both geographically and new species confirmations throughout the major corn and soybean producing states. With the spread of glyphosate resistant weeds, weed control programs have become more complex and growers across of the United States have adopted the use of preemergence herbicides. The most significant resistant weed species in the US is glyphosate resistant Palmer amaranth. Glyphosate resistant Palmer amaranth (*Amaranthus palmeri*) has caused millions of dollars in crop losses each year in many Southern states and has recently been documented in Northern Indiana, Southern Illinois, Missouri, and Michigan. Replicated trials were established to evaluate the preemergence control of Palmer amaranth utilizing Fierce herbicide throughout the Midwest and Southern areas of the US from 2007 and 2012. Weed control ratings were taken 28 and 56 DAT with no postemergence herbicide application made until after the 56 DAT rating. The objective of these trials was to determine the length of residual Palmer amaranth control comparing commonly used herbicides to Fierce herbicide in US soybean production. Treatments in these trials included Valor (flumioxazin 0.063 lb ai/A and 0.096 lb ai/A), Fierce (flumioxazin 0.063 lb ai/A + pyroxasulfone 0.08 lb ai/A, flumioxazin 0.079 lb ai/A + pyroxasulfone 0.1 lb ai/A, flumioxazin 0.095 lb ai/A + pyroxasulfone 0.12 lb ai/A), Authority Assist (sulfentrazone 0.13 lb ai/A + imazethapyr 0.026 lb ai/A), Authority First (sulfentrazone 0.124 lb ai/A + 0.016 lb ai/A), Prefix (s-metolachlor 1.09 lb ai/A + fomesafen 0.238 lb ai/A, Optill (saflufenacil 0.022 lb ai/A + imazethapyr 0.063 lb ai/A), Authority MTZ (sulfentrazone 0.124 lb ai/A + metribuzin 0.186 lb ai/A), Authority XL (sulfentrazone 0.155 lb ai/A + 0.02 lb ai/A), and an untreated check. Fierce herbicide applied preemergence can provide long residual control of Palmer amaranth compared to many of the industry standards in US soybean production.

A NEW SMARTPHONE APP FOR QUICK REFERENCE OF SPRAY QUALITY FOR GROUND APPLICATIONS.

Ryan S. Henry*[1], William E. Bagley[2], Lowel 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 (33)

Understanding droplet size from pesticide applications is critical for growers and professional applicators to make the best decision for maximizing pesticide efficacy while minimizing drift potential. The droplet size and spray quality of a pesticide application can be influenced by a variety of factors, including nozzle type, orifice size, operating pressure, and chemistry of the spray solution. Growers and pesticide applicators have numerous choices in regards to these factors, but it is difficult to obtain accurate and timely information on these factors' cumulative effect on the droplet size and spray spectrum. To aid growers and applicators in this regard, a custom iPhone and Android application (app) has been created and published. This free app allows the user to quickly determine the droplet size and quality of an application with user-defined parameters. The app also allows the user to save and/or send the results to another party in real time. The data for this app is generated using a low speed wind tunnel and laser diffraction system at the West Central Research and Extension Center in North Platte, NE. As the database for the app grows, it will further aid the end users across the US and the world to make an informed decision before making a pesticide application.

INFLUENCE OF NOZZLE TYPE AND SPRAY VOLUME ON HERBICIDE COVERAGE AT VARIOUS HEIGHTS IN THE CANOPY OF SOYBEAN GROWN IN 15. Travis Legleiter*, William G. Johnson; Purdue University, West Lafayette, IN (34)

A trial was conducted in the summer of 2012 to evaluate the influence of spray nozzle type and spray volumes on spray coverage at various heights in 30.5 cm tall soybeans. A factorial design was used with nozzle type and spray volume as main plot factors and collection card height and inter-row placement as subplot factors. Trials were laid out in a randomized complete block with four replications. Spray nozzles 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. Eighteen water sensitive cards were placed in a randomized grid within each plot, representing heights of 30.5, 20.3, and 10.2 cm above the ground and inter-row placements representing the 0%, 75% left or right, and 93% left or right of the inter-row center. Spray coverage area was not significantly different between inter-row spacing, although differences were observed between canopy heights with coverage being greatest at the 30.5 cm height and lowest at the 10.2 cm height. At all canopy heights a significant difference was observed between spray volumes for all nozzle types with 144 L/Ha volumes having significantly higher coverage. The Turbo Tee Induction nozzles resulted in less spray coverage at the 30.5 and 20.3 cm heights when applied at the 144L/Ha volume.

TANK MIXTURE OF HYDROPHILIC AND LIPOPHILIC HERBICIDES WITH ADJUVANTS. Devin A. Wirth*[1], Rich Zollinger[2], Angela J. Kazmierczak[2]; [1]NDSU, Fargo, ND, [2]North Dakota State University, Fargo, ND (35)

An experiment was conducted near Hillsboro, ND, to evaluate the efficacy of glyphosate (unloaded formulation) and saflufenacil with different adjuvants on four weed species: flax (*Linum usitatissimum L.*), amaranth (*Amaranthus hypochondriacus L.*), quinoa (*Chenopodium quinoa C.*), and tame buckwheat (*Fagapyrum esculentum L.*). Glyphosate is a hydrophilic herbicide which most oil adjuvants tend to antagonize. Saflufenacil is a lipophilic herbicide that does not mix well with nonionic surfactants and fertilizer adjuvants. The field study compared different combinations of fertilizers, nonionic surfactants plus AMS (NIS+AMS), petroleum oil concentrates (POC), methylated seed oils (MSO), and high surfactant oil concentrates (HSOC). The greatest phytotoxicity occurred when using an HSOC with a NIS+AMS. HSOC adjuvants are POC or MSO based products containing 20-50% surfactant and a minimum of 50% oil and differ from POC adjuvants which contain 83% phytobland mineral oil plus 17% emulsifier. HSOC adjuvants enhance oil soluble herbicides and do not antagonize glyphosate. This was true with MSO-HSOC adjuvants (Destiny HC), which enhanced the herbicide combination when added with NIS+AMS adjuvants like Class Act Flex or Class Act NG. Class Act Flex has a higher surfactant to AMS ratio than Class Act NG, which helped retention and deposition of the herbicides. Evaluations were taken 14 and 28 days after treatment. Regrowth occurred 28 days after treatment, especially in amaranth and quinoa. It was concluded that saflufenacil, a contact herbicide, caused rapid phytotoxicity and prevented glyphosate from translocating throughout the plant.

PROPOSED DICAMBA APPLICATION REQUIREMENTS FOR ROUNDUP READY® XTEND CROPPING SYSTEM. Joe Sandbrink*[1], Jeff N. Travers[1], Christopher D. Kamienski[2], John B. Willis[3]; [1]Monsanto, St. Louis, MO, [2]Monsanto Company, Washington, IL, [3]Monsanto, Hanson, KY (36)

Pending regulatory approvals, the Roundup Ready® Xtend Crop System includes the simultaneous launch of a new soybean product with tolerance to both glyphosate and dicamba. Roundup Ready® 2 Xtend and a low volatility premix formulation of dicamba and glyphosate. The system is designed to provide more consistent control of glyphosate-resistant and tough to control weeds. Monsanto also intends to launch new low volatility formulations of dicamba for over-the-top use on Roundup Ready® 2 Xtend Soybeans. A premix of dicamba and glyphosate will be branded as Roundup® Xtend, and a stand-alone formulation of dicamba will be branded as XtendiMax™. To ensure the highest level of on-target application and herbicide performance, Monsanto will also announce Application Requirements for the Roundup Ready Xtend Crop System. Growers will continue to use residual herbicides in the Roundup Ready PLUS™ program to maintain a sound weed resistance management strategy. Dicamba product labels will increase application accuracy compared to older products and uses. Targeted weeds should be less than four inches tall. Spray nozzles must provide very coarse, extremely coarse or ultra coarse droplets. Spray gallonage must be at least 10 GPA, and spray ground speed must be less than 15 mph. Drift reduction agents should be used, and spray boom height should be 20-24 inches above the canopy. Roundup Xtend and XtendiMax should be applied when winds are 10 mph or less. Growers are encouraged to check local sensitive crop registries (e.g. DriftWatch, others) before making applications, and to pay special attention to both wind direction and speed. Growers will also be required to maintain the required label buffer to protect sensitive areas. It is very important that growers triple rinse their sprayers according to label directions after using Roundup Xtend or XtendiMax.

SPRAY QUALITY EFFECTS WITH GLUFOSINATE AND ADDITIVES.

Angela J. Kazmierczak*[1], Rich Zollinger[1], William E. Bagley[2]; [1]North Dakota State University, Fargo, ND, [2]Wilbur-Ellis, San Antonio, TX (37)

EPA regulation through drift reduction technology (DRT) is imminent. Label changes that include language will force applicators to use a more course spray quality and include field borders to decrease the occurrence of drift onto off-target species. Concerns have been raised as to how spray quality recommendations on herbicide labels may impact the efficacy of groups of herbicides, specifically contact herbicides. Preliminary research has shown that herbicide efficacy decreases as spray droplet size increases. A field experiment was conducted near Hillsboro, North Dakota to evaluate the effect of spray quality on efficacy with glufosinate. Treatments included glufosinate alone, and in combination with ammonium sulfate (AMS), non-ionic surfactant (NIS), methylated seed oil (MSO), high surfactant oil concentrate (HSOC) all at three spray qualities; fine, coarse, and ultra coarse. Applications were made with an ATV spray unit to four species that represent weed species in plant architecture and morphology which include: flax (*Linum usitatissimum*), quinoa (*Chenopodium quinoa*), amaranth (*Amaranthus hypochondriacus* L., x *Amaranthus hybrid*), and tame buckwheat (*Fagopyrum esculentum*). Visual evaluations were recorded 14 and 28 DAT on a scale of 0 to 100, 0 = no resposnse, 100 = plant death. In general, treatments that received an application with a fine spray quality exhibited greater phytotoxicity 14 DAT. At the same evaluation, treatments that included HSOC and AMS provided the greatest control (greater than 83%) of flax and amaranth with the fine spray quality, 77% with the coarse, and 63% with ultra coarse. The decline of control was observed as a trend as spray droplet size increased.

REDUCTION IN DRIFT AND VOLATILITY OF ENLIST™ DUO WITH COLEX-D™ TECHNOLOGY.

David E. Hillger*[1], Kuide Qin[2], David M. Simpson[1], Patrick Havens[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Indianapolis, IN (38)

Dow AgroSciences is committed to stewardship of the Enlist™ Weed Control System. Enlist Duo herbicide (GF-2726) featuring Colex-D Technology will be a new herbicide formulation with reduced drift potential, volatility, and odor, as well as improved handling characteristics. A key component of Colex-D Technology is a new 2,4-D choline + glyphosate formulation with proprietary technology designed to reduce off-target particle movement under typical application conditions (drift) and movement due to vapor loss (volatility). Wind tunnel and field experiments were conducted to measure downwind deposition of GF-2726 following application. A comparison of GF-2726 versus a tank mix of 2,4-D dimethylamine (DMA) and glyphosate DMA, both sprayed with nozzles producing a medium droplet size (ASAEB S572.1 classification), was made in a wind tunnel at 11.2 km/h simulated wind speed. The amount of GF-2726 spray solution captured 2 m from the point of release was 57% less than a comparable tank mix of 2,4-D dimethylamine (DMA) and glyphosate DMA The reduction from GF-2726 was 73% when the nozzle tip producing coarse to very coarse droplets was used under the same conditions. In a large-scale field experiment, three different droplet size classes were evaluated using a 140 L/ha spray delivery volume. Greatest reduction in drift resulted when GF-2726 was applied through nozzle tips with a coarse droplet rating. Drift reduction was more than 90% compared to drift of 2,4-D DMA + glyphosate DMA applied with medium droplet nozzle tips. To characterize the volatility potential of the novel 2,4-D choline formulation, multi-year field experiments at four locations were conducted. Large, multi-hectare field plots were treated with a single application of either 2,4-D ethylhexyl ester; 2,4-D DMA; 2,4-D choline salt or the GF-2726 formulation. Airborne concentrations of herbicides were measured at several sampling points surrounding the treated area at distances of 5 and 15-m from the treatment edge, respectively. Volatility emissions from the 2,4-D choline formulation was 96% less than emissions from the 2,4-D ester treatment and 88% less than emissions from the 2,4-D DMA. In wind tunnel and field experiments, GF-2726 applications consistently reduce particle drift and volatility potential with built with Colex-D Technology compared to tank-mixtures of 2,4-D DMA + glyphosate DMA. ®™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Components of the Enlist Weed Control System have not yet received regulatory approvals; approvals are pending. The information presented here is not an offer for sale. Enlist Duo herbicide is not yet registered for sale or use as a component of the Enlist Weed Control System. Always read and follow label directions. ©2012 Dow AgroSciences LLC

PRE AND POSTEMERGENCE HERBICIDES ON WEED SUPPRESSION IN A KENTUCKY BLUEGRASS (*POA PRATENSIS*) AND PERENNIAL RYEGRASS (*LOLIUM PERENNE*) SYSTEMS WITH A CONVENTIONAL SPRAYER AND AN ULTRA-LOW VOLUME SPRAYER.

J Connor Ferguson*[1], Roch E. Gaussoin[1], John A. Eastin[2], Matt D. Sousek[3], Greg R. Kruger[4]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kamterter LLC, Waverly, NE, [3]University of Nebraska-Lincoln, Mead, NE, [4]University of Nebraska-Lincoln, North Platte, NE (39)

Field studies at the University of Nebraska-Lincoln: John Seaton Anderson Turfgrass Research Facility near Mead, NE were conducted to determine efficacy correlated between an ULV (Ultra-Low Volume) sprayer (Kamterter, Waverly, NE 68462) and a conventional sprayer (Toro Multi-Pro 1200, The Toro Company, Bloomington, MN 55420). The first study contained two treatments for each sprayer and an untreated check arranged in a randomized complete block design with four replications. The treatments selected were 2,4-D + dicamba + MCPP (Trimec Classic, PBI/Gordon Corporation, Kansas City, MO 64101) at 2326 g ae ha^{-1} + 248 g ae ha^{-1} + 622 g ae ha^{-1}, respectively and mesotrione (Tenacity, Syngenta Crop Protection Inc, Greensboro, NC 27419) at 224 g ai ha^{-1}. The mesotrione treatments were made in split applications of 112 g ha^{-1}. The first application was made at the time of the 2,4-D + dicamba + MCPP application on June 8th, 2012 and then the second application was made three weeks later on June 28th, 2012 . Treatments with the conventional sprayer were applied at 561 Lha^{-1} with XR11006 nozzles (Teejet Technologies, Wheaton, IL 60187) at 310 kPa and a speed of 5 km hr^{-1}. Treatments with the ULV sprayer were applied at 19 L ha^{-1} with proprietary nozzles at 6 kPa air pressure and a speed of 5 km hr^{-1}. The ULV sprayer has no liquid pressure which differs from the conventional sprayer. The dandelion study was applied over a mixed stand of Kentucky bluegrass (*Poa pratensis* L.*)* and perennial ryegrass (*Lolium perenne* L.*)*. The ground ivy study was applied over turf type tall fescue (*Festuca arundinacea* Schreb.). The established turf was maintained at 7 cm and irrigated to prevent drought stress. One study was selected to compare 2,4-D + dicamba + MCPP and mesotrione efficacy between the two sprayers on dandelion (*Taraxacum officinale* G.H. Weber ex Wiggers) and the other study was selected to compare the efficacy on ground ivy *(Glechoma hederacea* L.*)*. Dandelion and ground ivy counts were taken at the time of application, 14, 28, and 56 days after treatment. Two additional studies were conducted to compare the efficacy between a conventional sprayer and an ULV sprayer. The first study compared a 2,4-D + dicamba + sulfentrazone + triclopyr (T-Zone, PBI/Gordon Corporation, Kansas City, MO 64101) solution at 1427 g ae ha^{-1} + 109 g ae ha^{-1} + 33 g ai ha^{-1} + 377 g ai ha^{-1} respectively on ground ivy suppression in established turfgrass between a conventional sprayer and an ULV sprayer. The second study compared the two sprayers with a pre-emergent herbicide to compare the efficacy of a 1736 g ai ha^{-1} pendimethalin (Pendulum Aqua Cap, BASF Corporation, Research Triangle Park, NC 27709) solution on large crabgrass *(Digitaria sanguinalis (L.) Scop.)* suppression in established turfgrass. Results showed no difference in weed suppression for sprayer type in all four studies. The ULV sprayer suppressed weeds similarly to the conventional sprayer even with a fifteen-fold decrease in carrier volume across different herbicide modes-of-action in all of the studies. Results indicate that the Kamterter ULV sprayer system would be a useful and effective management option for turfgrass managers for weed control.

WEED CONTROL AND CROP RESPONSE FROM NONSELECTIVE HERBICIDES APPLIED WITH SPRAY HOOD TECHNOLOGY IN CORN, YEAR TWO.

Damian D. Franzenburg*[1], Micheal D. Owen[2], Dean M. Grossnickle[3], James F. Lux[1]; [1]Iowa State University, Ames, IA, [2]ISU, Ames, IA, [3]Iowa State University, Gilbert, IA (40)

Successful spray hood technology may provide additional chemical weed control alternatives where effective options are limited by the presence of weeds with evolved resistance(s) to specific herbicides. Spray hood technology provides a physical barrier between the crop and herbicide to achieve positional selectivity rather than requiring the use of transgenic crops or a more limited pool of herbicides with crop selectivity due to natural tolerance. Research investigating crop safety and herbicide efficacy using spray hood technology was conducted in 2011, near Ames, Iowa and presented at the 2011 NCWSS annual meeting. Control of several different weed species 15 days after application (DAA) ranging from 93 to 99% was observed for several nonselective herbicide tank mix treatments. However, corn injury at 7 DAA was also significant (17 to 35%) for nonselective treatments. The explanation was offered that a concentration of spray fines may have accumulated within the spray hood as the nozzle tips were charging to begin each treatment. The concentration may have dropped after the spray hood began moving into the plot area, and fines escaped the hood. This explanation also seemed appropriate for the observed gradient of less injury moving from the front to back of the plots. Another study was conducted near Fernald, Iowa, in 2012, at a grower site with a history of poor control of common waterhemp (*Amaranthus tuberculatus*, *A. rudis*, or *A. tamariscinus*) by HPPD inhibiting herbicides. The experimental design was randomized complete block with three replications. Corn with stacked resistance to glyphosate and glufosinate was planted on April 25 at 76 cm row spacing on soybean ground prepared by spring field cultivation. Plots were 3 by 7.6 m. Metolachlor &

atrazine was applied to the entire study at 2.43 kg/ha following planting. The limited capacity of the plot tractor could not facilitate a directed postemergence (DPOST) and hood application, simultaneously. Consequently, on June 5 a DPOST tank mixture of diflufenzopyr plus dicamba, mesotrione, and atrazine was applied with a hand boom at 20 GPA with the nozzles directed at the base of corn rows for all plots at 0.20, 0.11 and 0.56 kg/ha, respectively. Tank mixture additives for the DPOST treatment included 2.5 and 1.0% v/v liquid AMS and COC, respectively. The DPOST application was conducted immediately before the hood sprayer application and utilized Spraying Systems OC02 nozzle tips that were mounted to the exterior of the hood for such applications. The spray hood was equipped with 3 Spraying Systems fixed nozzle tips inside of the hood for application between corn rows. The center tip was a 6502E and two side tips were 9502EVS. The herbicide treatments being investigated were applied through these tips, within the spray hood at 20 GPA, while powered with compressed CO_2. The Wilmar Fabrication 915 Spray-Hood used in this research is normally powered by two hydraulic pumps and tanks operating to apply herbicide treatments unique for each the hood and the DPOST application to corn rows, simultaneously. All spray hood treatments were tank mixtures that included metolachlor at 1.07 kg/ha and liquid AMS at 2.5% v/v. Paraquat and ametryn were applied at rates of 0.56 and 1.12 kg/ha, respectively, alone and tank mixed together. Metribuzin (0.21 kg/ha) was tank mixed with paraquat. Glufosinate (0.60 kg/ha) was applied alone, and tank mixed with ametryn. Saflufenacil was applied alone at 0.03 kg/ha. COC was included at 1% v/v for all treatments except for those with glufosinate. No treatments caused corn injury at 2, 15, 28 and 43 days DAA. All treatments provided at least 98% control of common waterhemp at 15, 28 and 43 DAA. Longer alleys were used in the 2012 experiment to allow the hood sprayer to travel some distance after the nozzle tips had been charged before entering into the plots. More down pressure was applied on the hood in 2012 to ensure that it was riding on the soil surface during application. Considering that the research was repeated in 2012 and demonstrated efficacious weed control without crop injury, further research should be conducted on a larger scale with equipment that utilizes the hood and DPOST application equipment, simultaneously. Future research should use a larger scale of equipment and space. A range of crop and weed sizes and species at varied application volume and ground speed should be investigated.

FLOW RATES OF NEW GROUND APPLICATION NOZZLES. Annah Geyer*[1], Ryan S. Henry[2], Lowel Sandell[3], William E. Bagley[4], Greg R. Kruger[2]; [1]University of Nebraska Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]Wilbur-Ellis, San Antonio, TX (41)

Growers in the US have the option of selecting ground application nozzles from several manufacturers, and each manufacturer produces a variety of nozzle types. All nozzles are not created equally even though they are made in the same facility and in the same way. Each nozzle has unique operating parameters that can affect the final quality of the application. For example, operating pressure and flow rate are important for controlling droplet size and the total volume applied. To ensure a successful pesticide application on fields, growers must be sure all nozzles on their equipment have similar flow rates. A set of studies was conducted at the West Central Research and Extension Center, University of Nebraska-Lincoln in North Platte, NE to examine the variability of flow rate from eleven nozzles each with four orifice sizes. A total of ten nozzles for each orifice size by nozzle type combination were used in this experiment. The data showed a wide variability of flow rate within and between nozzle types. Flow rates ranged from 0.23 to 0.28 for 025 nozzles, 0.28 to 0.36 for 03 nozzles, 0.37 to 0.46 for 04 nozzles and 0.47 to 0.56 for 05 nozzles. The result of this study illustrates the need for applicators to check nozzle variability in terms of flow rate prior to making pesticide applications.

DROPLET SIZE ANALYSIS OF A GLYPHOSATE SOLUTION AS INFLUENCED BY CARRIER VOLUME, NOZZLE, AND PRESSURE. Cody F. Creech*[1], Annah Geyer[2], Ryan S. Henry[1], Lowel Sandell[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE (42)

Several studies have investigated droplet size from glyphosate solutions and its effects on spray patterns, potential drift, and efficacy. The objectives of this study were to elucidate the effects of nozzle, herbicide concentration, and pressure on the droplet size of a glyphosate (RoundUp PowerMax at 37g ae/ha) spray spectra. Droplet size and distribution of four herbicide concentrations (47, 94, 140, and 187 L/ha) was measured using laser diffraction. The spray droplet spectra of five commonly used nozzles (AI, AIXR, TT, TTI, and XR), using both medium and large orifices for each nozzle (11003, 11005), was investigated at low, medium, and high pressure (2.76, 4.14, 5.52 bar [40, 60, 80 psi]). In nearly every case, droplet size increased as the herbicide concentration became more diluted. The exception was the TTI11003 nozzle which behaved inconsistently when compared to the other nozzles. The droplet size of every combination of nozzle and

GPA decreased as the pressure increased. The greatest change in Dv10 values was noted between the low and medium pressures. The most important factor in determining droplet size of a glyphosate spray spectra is the nozzle, followed by pressure, and lastly herbicide concentration.

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], Neha Rana[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska - Lincoln, Lincoln, NE (43)

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 publication that can be utilized by the general public. Therefore, we developed a training manual that describes the proper use of propane fueled flaming as a weed control tool in major agronomic crops (corn, soybean and sunflower). 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. Manual is free, it can be downloaded in a pdf format from the following website: http://www.agpropane.com/ContentPageWithLeftNav.aspx?id=1916

TRAINING ON HERBICIDE MODE OF ACTION AND CROP INJURY SYMPTOMS. Jessica L. Rinderer*[1], Bryan G. Young[1], Sara M. Allen[2], Randy McElroy[2], Carolina Medina[2], Jody R. Gander[2]; [1]Southern Illinois University, Carbondale, IL, [2]Monsanto Company, St. Louis, MO (44)

With multiple herbicide modes-of-action (MOA) being applied in postemergence applications as part of herbicide resistance management strategies there is a critical need for education and understanding of herbicide injury symptoms. Since agronomists and seed sales representatives often serve as a liaison between the research and production sides of agriculture, effective training should facilitate improved understanding of herbicide mode-of-action at the grower level as well. Mode-of-action training is also justified for proper diagnosis of herbicide spray drift and tank contamination issues. Field research plots were established in Farina, IL in 2011 and in Farina, IL, Belleville, IL and Edwardsport, IN in 2012 to educate agronomists and seed sales representatives about herbicide injury symptoms on corn and soybean. Herbicides representing 13 different mode-of-action categories were applied at rates ranging from 0.25 to 1X (full labeled use rate) postemergence 10 to 14 days prior to demonstration. Herbicides were applied to a variety of crops including milo, glyphosate-resistant corn, glyphosate- and glufosinate-resistant corn, imidazolinone herbicide-resistant corn, conventional (not herbicide resistant) corn, glyphosate-resistant soybean, glyphosate-resistant and sulfonylurea-tolerant soybean, glufosinate-resistant soybean, and non-genetically modified soybean. Attendees were educated on expected crop symptomology from the various mode-of-action categories and provided with written materials to reinforce their training. The training was designed to target audiences with a range in experience and knowledge on herbicide MOA. Basic/entry level: display MOA symptomology, provide literature on MOA, and highlight key plant symptoms for each herbicide MOA. Mid-level/refresher: show MOA symptomology, poll participants for key symptoms, and request participants point out symptoms in the demonstration plots. Advanced/high knowledge level: turn plot signs around for participants to identify unknown herbicide MOA based on symptomology specific to each MOA. Challenge level: unknown herbicide MOA plots, participants work in teams, provide blank answer sheet, grade sheets to acknowledge high scores. Participant feedback was very positive in terms of the different levels of training offered for groups with mixed knowledge levels with many indicating they have never received any previous training on herbicide MOA. Furthermore, participants suggested that repeated training on herbicide MOA would be justified for developing a comprehensive knowledge base that would translate into advanced field diagnosis skills.

SURVEY: IMPACT AND MANAGEMENT OF GLYPHOSATE-RESISTANT KOCHIA IN KANSAS. Amar S. Godar*[1], Phillip W. Stahlman[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (45)

Reports of inability to control kochia (*Kochia scoparia*) with glyphosate increased dramatically in the years following confirmed presence of glyphosate-resistant (GR) populations in 2007, in four separate populations in western Kansas. The objectives of this online survey were to document the spread and distribution of GR kochia in western Kansas and gather information on growers' response to the problem. The survey involved 52 crop consultants representing approximately 420,000 ha of western Kansas cropland. Participants were asked to provide information for three distinct time periods (before 2007, 2007-2010, and 2011-2012) specific to their areas of operation. Within the entire area surveyed, the percentage of kochia-infested fallow fields increased from 47 to 57 to 70%, respectively, in those consecutive time periods. The percentage of kochia-infested fields (both fallow and row-crops) in 2011-2012 was 67%, of which nearly half were GR populations. Thus, it is estimated that GR kochia currently infests nearly one-third of the cropland in western Kansas. Survey respondents reported the average use rate of glyphosate increased from 0.8 kg ae/ha before 2007 to 1.2 kg ae/ha in 2011-2012. Similarly, glyphosate use frequency before 2007 increased from 2.1 applications per season to 3 applications in fallow and 2.7 applications per season in GR crops in 2011-2012. The spread of GR kochia has changed management practices. Total dependency on glyphosate for weed control in GR crops decreased from 49 to 15% of the crop fields during the survey years. This result coupled with the estimated impact of GR kochia suggests an obligatory shift towards alternative weed management programs in GR kochia-infested fields, and more importantly, demonstrates increased grower awareness of the need to adopt proactive herbicide resistance management practices. Though several survey respondents reported success using other herbicides in addition or in place of glyphosate in early spring, often prior to kochia emergence, more than one-third of respondents reported inconsistent results with alternative kochia control practices other than tillage.

REMOTELY PILOTED AIRCRAFT SYSTEMS AND HIGH RESOLUTION COLOR INFRARED IMAGERY FOR ASSESSING HERBICIDE DRIFT AND CROP CONDITIONS. Dallas Peterson*, Deon van der Merwe, Kevin Price, David Burchfield, Cathy Minihan; Kansas State University, Manhattan, KS (46)

Crop growth and development can vary dramatically within a field due to a variety of factors, including differences in soil properties, terrain, moisture, nutrients, plant stands, pest problems, and herbicide effects. Field patterns and the magnitude of differences in crop growth and development often can be difficult to assess at ground level. Aerial photography has been used to get a better perspective on spatial and spectral patterns within fields. Color and infrared photography can help discern differences in crop growth and development that may not be evident in the normal color ranges of the human eye. However, there may be a number of limitations to using conventional aerial photography to assess crop conditions, including flight availability, costs, scheduling, flying conditions, and spatial resolution. One alternative to conventional aerial photography to assess field conditions is to use remotely piloted, or small Unmanned Aircraft Systems (sUAS) , in combination with a high resolution color infrared digital camera. Detailed aerial color infrared images of a simulated drift study were collected and produced using the following procedures. A Canon Powershot S100 was modified to allow visible blue and visible green light between 400 nm and 580 nm, and the visible red edge to near infrared transition between 680 nm to 780 nm to pass to the camera sensor for image collection. The camera was mounted on a Zephyr sUAS flying wing model aircraft manufactured by Ritewing RC. The aircraft is powered by an outrunner brushless electric motor. The airframe consists of extruded polypropylene (EPP) foam, with internal and external reinforcement using fiberglass spars and laminating film. Control and stabilization surfaces are constructed from balsa wood and corrugated plastic. Electrical power for the autopilot, flight control servos, and electric motor is provided by two lithium polymer batteries in parallel. Command and control is achieved through the use of the Hitec Aurora 9 R/C system, and Ardupilot Mega 2.0 autopilot system. The camera was set to continuous shoot mode to record one image every four seconds. The aircraft was flown over the test area several times and images recorded. RAW format images were converted to TIFF format in Adobe Photoshop CS6 (ver. 13.0.1 x64). A photogrammetric model was then constructed from overlapping images using Agisoft PhotoScan Standard Edition (ver. 0.9.0 build 1586). The process included photo alignment, 3D model construction, and adding reflectance data to the 3D model to produce an orthophoto of the entire field. The photogrammetry-derived orthophoto was converted to a data layer in ESRI ArcMap 10.0 (build 2414) for image analysis. Pixel size at the altitude flown over the field was approximately 2 cm x 2 cm. Multiple images with different color separations of the field were created to assess differences in crop growth and development. Utilizing different color separations illustrated different patterns in the field. The patterns of differential crop growth appeared to be primarily a function of variability in soil properties and available soil moisture rather than herbicide drift damage. Hot, dry environmental conditions, the type of herbicide injury, and the timing of the photography may have minimized the ability to detect the drift injury. Drift injury was primarily distorted growth and height reduction, and not chlorosis or dramatic biomass reductions. The aerial imagery was taken about 5 weeks after application, while herbicide response was probably greatest at 3 to 4 weeks after application. Remotely piloted aircraft systems and high resolution color infrared imagery appears to be an economical method to discern different patterns of crop growth within a field. The type of crop response, however, may influence its effectiveness, and the cause for different growth patterns may not always be easily determined.

BASF'S ON-TARGET APPLICATION ACADEMY: EDUCATING GROWERS. Walter E. Thomas*, Maarten Staal, Steven J. Bowe, Luke L. Bozeman, Daniel Pepitone; BASF Corporation, Research Triangle Park, NC (47)

The On-Target Application Academy is a one-of-a-kind educational opportunity to provide growers extensive hands-on training for better awareness of herbicide application best practices that help mitigate spray drift – which is a continuous area of focus for the agricultural industry. Understanding that today's herbicide environment is more complex, BASF wants to continually support growers and help them achieve the most effective weed control possible with today's emerging product and equipment innovations. According to the BASF Grower Perception Survey conducted in 2011, 80% of the respondents indicated that they self-apply herbicides to their crops. In addition, more than one-third said they were interested in taking a herbicide self-application training seminar. Based on the responses from growers, BASF and TeeJet® jointly initiated the On-Target Application Academy to provide field based training utilizing recognized application technology experts. The Academy has focus areas that are derived from herbicide application best practices including proper nozzle selection, appropriate calibration and boom placement and impact of environmental conditions. The On Target Application Academy will be conducted at various locations throughout the US in 2013.

WILD VIOLET CONTROL VARIES WITH HERBICIDE SELECTION AND TRICLOPYR RATE. Dan V. Weisenberger*[1], Aaron J. Patton[2]; [1]Purdue University, Lafayette, IN, [2]Purdue University, W. Lafayette, IN (48)

Violet (*Viola* spp.) is a colony forming perennial broadleaf that is hard to control, yet information is lacking on its control. Two experiments were conducted at the Purdue University, Life Sciences Greenhouses. The first experiment looked at the efficacy of various herbicides. The second experiment looked at a range of triclopyr rates to determine the rate needed to achieve control. Violets were collected in October and November 2011 from a residence in Lafayette, IN and immediately transplanted in the greenhouse. The plants were transplanted into 10 cm diameter pots filled with a silt loam soil. The violets were fertilized monthly and watered daily until the initiation of the experiments. The herbicide efficacy experiment was conducted twice with the applications being made on 18 April and 29 May, 2012. Treatments included 2,4-D amine (1.12 kg ha^{-1}); 2,4-D ester (1.12 kg ha^{-1}); MCPA (1.12 kg ha^{-1}); MCPP (1.12 kg ha^{-1}); 2,4-DP (1.12 kg ha^{-1}); triclopyr (1.12 kg ha^{-1}); quinclorac (0.84 kg ha^{-1}); triclopyr (1.12 kg ha^{-1}) + quinclorac (0.84 kg ha^{-1}); 2,4-D ester (1.12 kg ha^{-1}) + 2,4-DP (1.12 kg ha^{-1}); 2,4-D ester (1.12 kg ha^{-1}) + triclopyr (1.12 kg ha^{-1}); 2,4-D ester (1.12 kg ha^{-1}) + 2,4-DP (1.12 kg ha^{-1}) + triclopyr (1.12 kg ha^{-1}); and an untreated check. The herbicides were applied in 814 L ha^{-1} water at 207 kPa with CO_2 pressurized boom sprayer equipped with an XR80015VS flat-fan nozzle. The pots were arranged in a randomized complete block design on the greenhouse bench. Data collected were percent epinasty, percent necrosis, chlorophyll concentration index (CCI) and dry tissue following regrowth. Data was analyzed using SAS. The epinasty, CCI, and regrowth data could be combined over experimental runs. The triclopyr rate experiment was conducted twice with the applications being made on 29 May and 7 September 2012. Treatments included triclopyr at 0 kg ha^{-1}, 0.14 kg ha^{-1}, 0.28 kg ha^{-1}, 0.56 kg ha^{-1}, 0.84 kg ha^{-1}, and 1.12 kg ha^{-1}.The herbicides were applied in the same manner as the efficacy experiment and the experimental design and data collection was also the same. The data from both experiments was analyzed in SAS. Regression analysis was performed with SigmaPlot. Efficacy Experiment: At 7 days after application (DAA) all treatments containing triclopyr and the quinclorac treatment had the lowest CCI values ranging from 3.3 to 4.2 compared to 2,4-D ester (6.2) and the untreated check (6.0). On subsequent rating dates, triclopyr had the lowest CCI values and less than all other treatments. Epinasty ranged from 71 to 89%14 DAA for triclopyr containing treatments. By 42 DAA all treatments containing triclopyr had necrosis ratings ranging from 80 to 96% in run 1 and 58 to 80 percent in run 2. Comparatively, necrosis ratings for other treatments ranged from 8 to 25%, 42 DAA. Regrowth following the harvest for the treatments containing triclopyr ranged from 0.02 g to 0.15 g dry tissue and were lower than all other treatments that had values ranging from 0.46 g to 0.62 g dry tissue. Triclopyr provided the greatest wild violet efficacy in our experiment. The treatments containing triclopyr were not different from the triclopyr treatment alone indicating that there was no synergism between herbicide combinations. Rate Experiment: The triclopyr rate experiment showed similar trends regardless of data collection type. As triclopyr rate increased, violet epinasty and necrosis increased while CCI decreased. In our experiment, triclopyr applied at 0.84 kg ha^{-1} and 1.12 kg ha^{-1} provided the best efficacy and typically provided similar levels of control. Many turf herbicides containing triclopyr are available to turf professionals but most apply ≤0.63 kg ha^{-1} triclopyr when applied at the high label rate. Thus, to improve violet control, turf managers should apply triclopyr by itself at 0.84 to 1.12 kg ha^{-1} or tank-mix 0.56 kg ha^{-1} triclopyr (maximum label allowable amount when tank-mixing) with another triclopyr containing herbicide.

EFFICACY OF AMINOCYCLOPYRACHLOR BLENDS ON PASTURE WEEDS.

Susan K. Rick*[1], Jeff H. Meredith[2]; [1]DuPont, Waterloo, IL, [2]DuPont, Memphis, TN (49)

Aminocyclopyrachlor is a new herbicide candidate under development by DuPont Crop Protection. Premixture blends with other herbicides including sulfonylureas are being investigated for broadleaf weed control in pastures. The mixtures increase the spectrum of species controlled and will be beneficial in controlling or delaying the onset of ALS resistant species. Six trials were conducted in southern Illinois in 2011 and 2012 for control of various annual and perennial broadleaf weeds and brush weed species in pasture. Excellent control of species such as common ragweed (*Ambrosia elatior*), common cocklebur (*Xantium strumarium*) , ironweed (*Veronia baldwinii*), Japanese honeysuckle (*Lonicera japonica*) were observed. Three aminocyclopyrachlor blends have been submitted to the EPA; registration is pending.

CHEMICAL CONTROL OF ENGLISH IVY (*HEDERA HELIX*).

Joseph Thomas*[1], Gregory R. Armel[2], James Brosnan[1], Jose J. Vargas[3]; [1]University of Tennessee, Knoxville, TN, [2]BASF, Research Triangel Park, NC, [3]The University of Tennessee, Knoxville, TN (50)

English ivy (*Hedera helix*) is a woody perennial vine currently sold in the ornamental trade that has become invasive in many natural areas. English ivy forms dense monocultures that compete with surrounding vegetation for light, moisture and nutrients. Mature plants also climb trees potentially causing structural damage. Greenhouse research was conducted at the University of Tennessee (Knoxville, TN) to identify herbicides for English ivy control. English ivy plants were obtained from a commercial nursery and potted in 10.2 cm by 10.2 cm plastic pots with pine bark growing media. Plants were kept under natural light conditions and watered daily for the duration of the study. Two experimental runs were conducted during the spring of 2012. Each was arranged in a randomized complete block design with four replications. Fifteen herbicides were applied to English ivy at a rate labeled for broadleaf weed control (1x rate), as well as four times this labeled rate (4x rate). This 4x rate treatment was applied to identify which of these fifteen herbicides might provide any level of English ivy supression and might therefore be a valuable component in synergistic herbicidal mixtures. Treatments in this experiment included 2,4-D (1,120 and 4,480 g ai ha^{-1}), dicamba (1,120 and 4,480 g ai ha^{-1}), picloram (1,120 and 4,480 g ai ha^{-1}), aminopyralid (123 and 492 g ai ha^{-1}), quinclorac (840 and 3,360 g ai ha^{-1}), aminocyclopyrachlor (70 and 280 g ai ha^{-1}), metsulfuron-methyl (84 and 336 g ai ha^{-1}), sulfometuron-methyl (315 and 1,260 g ai ha^{-1}), imazapyr (1,120 and 4,480 g ai ha^{-1}), hexazinone (1,680 and 6,720 g ai ha^{-1}), tebuthiuron (2,688 and 10,752 g ai ha^{-1}), mesotrione (105 and 420 g ai ha^{-1}), fosamine (6,720 and 26,880 g ai ha^{-1}), glyphosate (4,500 and 18,000 g ai ha^{-1}), and triclopyr (2,100 and 4,200 g ai ha^{-1}). All herbicides were applied postemergence with a CO_2 backpack sprayer calibrated to deliver 215 L ha^{-1} English ivy control was visually rated on a 0 (i.e., no plant injury) to 100% (i.e., complete plant death) scale at 4, 6, 8, 10, and 12 weeks after treatment (WAT) relative to a non-treated check. At 12 WAT all aboveground biomass in each pot was harvested, oven dried at 80°C for 5 days, and weighed. By 12 WAT, the 1x rates of metsulfuron-methyl and imazapyr controlled English ivy 94% and 82%, respectively. Comparatively, the 1x rate of triclopyr and glyphosate only controlled English ivy 53% and 28%, respectively. At the 4x rate tebuthiuron, hexazinone and picloram controlled English ivy 93% to 99%, but provided less than 52% control of Engish ivy when applied at their respective 1x rate. The inherent activity of thsee herbicides at higher than labeled application rates suggest that they may be effective when used at labeled rates in combination with other active ingredients. Reductions in aboveground biomass supported visual evaluations of English ivy control. Our research suggests that metsulfuron-methyl, imazapyr, tebuthiuron, hexazinone, and picloram may provide options for English ivy management. Additional research is needed to explore these herbicides under field conditions and to understand impacts of tank mixtures of these products not only on Engish ivy but on native species grown in close proximity to Engish ivy.

SALTCEDAR CONTROL ON THE CIMARRON NATIONAL GRASSLANDS. Walter H. Fick*[1], Wayne A. Geyer[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Universsity, Manhattan, KS (51)

Saltcedar (*Tamarix ramosissima*) is a woody invasive species found in Kansas primarily along the Cimarron and Arkansas rivers. The objective of this study was to determine the impact of application date on the efficacy of 10 herbicides applied for saltcedar control. The study site was located on the Cimarron National Grasslands near Elkhart, KS. Nine herbicides were applied with a backpack sprayer at 467 L ha^{-1} total spray solutions with the addition of a 0.5% non-ionic solution. A basal treatment of 48 g L^{-1} triclopyr in diesel was also applied. All treatments were applied on August 3 and October 14, 2011 with 9 to 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. Results substantiated previous work with imazapyr at 1.2 and 2.4 g L^{-1}, imazapyr + glyphosate at 1.2 + 5.4 g L^{-1}, and imazapic at 2.4 g L^{-1} all providing greater than 70% control. The triclopyr in diesel treatment (48 g L^{-1}) provided greater than 60% control for both dates of application. Triclopyr + fluroxypyr (1.8 + 0.6 g L^{-1}), aminopyralid + triclopyr amine (0.3 + 3.6 g L^{-1}), aminopyralid + metsulfuron (0.26 + 0.05 g L^{-1}), aminopyralid + metsulfuron + triclopyr (0.26 + 0.05 + 1.2 g L^{-1}, and aminocyclopyrachlor + metsulfuron (0.9 + 0.2 g L^{-1} were all ineffective when applied on August 3. The triclopyr + fluroxpyr, aminopyralid + triclopyr amine, and aminocyclopyrachlor + metsulfuron treatments were all more effective when applied on the October 14 date providing 38, 44, and 50% control, respectively. Late summer precipitation, although below normal, may have contributed to the increased mortality following the October 14 treatments.

EFFECT OF ORGANIC MATTER ON HYBRID BERMUDAGRASS INJURY WITH PREEMERGENCE HERBICIDES IN SAND-BASED ROOTZONES. Patrick A. Jones*[1], James Brosnan[2], Dean A. Kopsell[3], Gregory K. Breeden[2]; [1]University of Tennessee Knoxville, Knoxville, TN, [2]University of Tennessee, Knoxville, TN, [3]The University of Tennessee, Knoxville, TN (52)

Preemergence (PRE) herbicides have been reported to injure both foliage and roots of hybrid bermudagrass [*C. dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy] established in sand. Research was conducted to evaluate the influence of organic matter content on hybrid bermudagrass injury following PRE herbicide applications to plants established in sand culture. Washed sod was established in mini-rhizotrons constructed with sand rootzones varying in organic matter (e.g., sphagnum peat mass) content (0.000, 0.003, 0.007, and 0.012 kg kg^{-1}). Herbicide treatments included indaziflam (35 and 52.5 g ha^{-1}) and prodiamine (840 g ha^{-1}). Bermudagrass injury was visually evaluated weekly after application using a 0 (no injury) to 100 (complete kill) scale. At 6 weeks after treatment (WAT) roots were washed free of debris and excised as close to the crown as possible. WinRhizo software was used to characterize root length (cm), root length density (cm cm^{-3}) (RLD), and root surface area (cm^2). Significant foliar injury was only observed with indaziflam at 52.5 g ha^{-1}. When applied to sand with 0.000 kg kg^{-1} organic matter injury measured 61% by 6 WAT. Comparatively, injury with indaziflam at 52.5 g ha^{-1} was reduced by 40% with plants established in sand with 0.007 kg kg^{-1} organic matter. Root length, RLD, and root surface area were greatest in sand rootzones with $\geq$ 0.007 kg kg^{-1} organic matter regardless of herbicide treatment; however, only indaziflam at 52.5 g ha^{-1} and prodiamine reduced root parameters relative to the untreated check. Data in the current study illustrate that organic matter content can affect above- and belowground injury following PRE herbicide applications to sand rootzones.

METHODS TO SAFEN MUSTARD SEED MEAL APPLICATIONS ON CREEPING BENTGRASS (*AGROSTIS STOLONIFERA* L.) PUTTING GREENS. Joseph G. Schneider*, John B. Haguewood, Xi Xiong; University of Missouri, Columbia, MO (54)

Mustard Seed Meal (MSM) is a byproduct following oil extraction from seeds. This material contains secondary metabolites termed glucosinolates, which can be converted into biocidal isothiocyanates. These volatile compounds exhibit activity on a wide range of turfgrass pests, including weeds. However, even marginal rates of MSM may detrimentally impact turf quality. Research was established to explore various methods of application which could reduce the potential injury of MSM to fine turf. Field experiments were established on ‘A4’ creeping bentgrass (*Agrostis stolonifera* L.) maintained as a typical golf course putting green. Plots were arranged in a randomized complete block design with 3 replications and the experiment repeated. Experiment 1 consisted of MSM mixed with sand at single rates of 1000, 2000, and 3000 kg/ha and applied by one of three methods: top-dressing, verticutting followed by topdressing, or aeration followed by topdressing. Experiment 2 consisted of all MSM rates used in experiment 1, but applications only included topdressing or soil aeration followed by topdressing. In addition, the MSM/sand mix in experiment 1 was allowed to remain as a 1.5 mm layer on the turf surface for the soil aeration followed by topdressing application method; in experiment 2 the MSM/sand was lightly brushed to fill the holes following aeration. Results from experiment 1 found that MSM at 2000 kg/ha or above caused visible injury (discoloration) to creeping bentgrass turf within 1week after treatment (WAT). At 1000 kg/ha, turf growth in the MSM topdressed following aeration plots was not significantly affected. Turf quality remained at 6 or above (acceptable level) throughout the experiment. In comparison, MSM at 1000 kg/ha topdressed directly over turf resulted in unacceptable turf quality (< 6) until 6 WAT. In experiment 2, MSM topdressed at 3000 kg/ha significantly reduced turf quality indicated by normalized difference vegetation index (NDVI) at 2 WAT. The same MSM rate, however, did not reduce turf quality when applied after aeration compared to the untreated control. Our results indicate that turf quality is least impacted when MSM/sand is applied to an aerated soil and moved away from contact with grass leaves.

CONTROL OF CRABGRASS ON CREEPING BENTGRASS (*AGROSTIS STOLONIFERA* L.) PUTTING GREENS USING PREEMERGENCE HERBICIDE. John B. Haguewood*, Xi Xiong; University of Missouri, Columbia, MO (55)

Crabgrass species (*Digitaria spp.*) are widespread annuals found on creeping bentgrass (*Agrostis stolonifera* L.) golf course putting greens. Pre-emergence herbicides are an effective technique for control of crabgrass, but tolerance of creeping bentgrass is a concern at putting green mowing heights (~3 mm). Newly developed, methiozolin is a cell wall biosynthesis inhibitor with strong activity as a pre-emergence herbicide for crabgrass. The objective of this research was to evaluate the use of methiozolin for control of crabgrass, duration of residual activity, and turfgrass tolerance. On April 6, prior to initial crabgrass emergence, a field trial was established on a creeping bentgrass putting green in Columbia, Missouri in 2012. Treatments included methiozolin at 0.5, 0.75 or 1.0 kg ai/ha as a single application or sequential applications. In addition, the pre-emergence herbicides bensulide, dithiopyr, indaziflam, bensulide + oxadiazon, and siduron were included as single or sequential applications, as well as an untreated control. Experimental design was a randomized complete block with four replications. Data collected included turfgrass quality, normalized difference vegetation index (NDVI), turfgrass phytotoxicity and percent crabgrass. All treatments, with the exception of siduron, reduced crabgrass density by ≥60% compared to the untreated control 8 weeks after initial treatment (WAIT). By 21 WAIT, plots treated with bensulide, dithiopyr and two applications of methiozolin (1.0 kg ai/ha) resulted in 93, 94, and 90% crabgrass control, respectively. Only plots that received bensulide + oxadiazon showed transient phytotoxicity following application, but turf quality was not reduced below an acceptable level (≤6). Methiozolin appears to result in a level of crabgrass control similar to commercially available compounds, with no apparent injury to creeping bentgrass.

MOWING HEIGHT EFFECTS ON PREEMERGENCE HERBICIDE EFFICACY FOR SMOOTH CRABGRASS CONTROL. Shane M. Breeden*[1], Daniel Farnsworth[2], James Brosnan[2], Gregory K. Breeden[2]; [1]Maryville College, Maryville, TN, [2]University of Tennessee, Knoxville, TN (56)

Smooth crabgrass (*Digitaria ischaemum*) is a problematic weed of warm- and cool-season turfgrass across the United States. While several preemergence (PRE) herbicides can effectively control smooth crabgrass, data describing the effects of certain turfgrass maintenance practices on PRE herbicide efficacy are limited. Research was conducted in 2012 to investigate the effects of mowing height on PRE herbicide efficacy for smooth crabgrass control in common bermudagrass (*Cynodon dactylon*) turf. Treatments included the factorial combination of two mowing heights (15 and 50 mm), six PRE herbicides (indaziflam, dithiopyr, oxadiazon, pendimethalin, prodiamine, and prodiamine + sulfentrazone), and two application regimes (single, sequential). Both regimes delivered the same rate of active ingredient for each herbicide; however, sequential regimes split this rate across two applications spaced eight weeks apart. Total application rates were as follows: indaziflam (35 and 52.5 g ha^{-1}), dithiopyr (560 g ha^{-1}), oxadiazon (4500 g ha^{-1}), pendimethalin (3360 g ha^{-1}), prodiamine (1680 g ha^{-1}), and prodiamine + sulfentrazone (1260 g ha^{-1}). Mowing height-by-application regime interactions were detected in smooth crabgrass control data 5 months after initial treatment (MAIT). Mowing height-by-herbicide interactions were also detected in smooth crabgrass control data collected 3, 4, and 5 MAIT as well. At the 15 mm mowing height, split application regimes provided greater smooth crabgrass control than single applications at 5 MAIT; however, no significant differences were detected between single and split application regimes at the 50 mm mowing height. By 5 MAIT, all herbicides except prodiamine provided greater smooth crabgrass control when applied to turf maintained at 50 mm compared to 15 mm. Data illustrate that mowing height can affect efficacy of PRE herbicides for smooth crabgrass control.

NON-TARGET-SITE RESISTANCE TO ALS INHIBITORS IN WATERHEMP. Jiaqi Guo*[1], Chance Riggins[2], Nicholas E. Hausman[1], Aaron G. Hager[1], Dean E. Riechers[1], Patrick Tranel[1]; [1]University of Illinois, Urbana, IL, [2]University of Illinois Urbana Champaign, Urbana, IL (57)

Numerous weed species have evolved resistance to ALS-inhibiting herbicides. Typically, resistance to ALS inhibitors is conferred by one of several possible point mutations in the ALS gene. For example, in waterhemp (*Amaranthus tuberculatus*), resistance to ALS inhibitors is often due to a point mutation resulting in a Trp574Leu amino acid substitution. During preliminary analysis of a waterhemp population from Illinois, two different resistance phenotypes were observed after treatment with ALS-inhibiting herbicides. Specifically some of the plants were highly resistant, with little or no apparent injury, whereas other plants displayed typical injury symptoms (chlorosis and stunting) but nevertheless were able to survive dosages lethal to sensitive populations. We hypothesized that the highly resistant plants possessed an ALS target-site mutation, whereas the moderately resistant plants possessed a different resistance mechanism. A PCR-based DNA marker was used to demonstrate that the highly resistant plants, but not the moderately resistant plants, contained the ALS Trp574Leu mutation. Plants that survived treatment with an ALS inhibitor but lacked this mutation were crossed to create a population (NTSR) for further investigation. Sequencing of the ALS gene from the NTSR population failed to identify one of the known mutations that confer resistance. The lack of target-site resistance will be confirmed using ALS enzyme assays. Greenhouse-based dose-response experiments were used to quantify resistance to ALS inhibitors in the NTSR population. The modest resistance observed in the initial preliminary experiment was again observed in the NTSR population, indicating that it is genetically heritable. The presence of multiple resistance mechanisms in waterhemp to ALS-inhibiting herbicides further illustrates this species adeptness at evolving resistance.

INHERITANCE OF PHENOXY RESISTANCE IN WILD RADISH (*RAPHANUS SATIVUS)*. Mithila Jugulam*[1], Natalie DiMeo[2], Michael Walsh[3], J. Christopher Hall[2]; [1]Kansas State University, MANHATTAN, KS, [2]University of Guelph, Guelph, ON, [3]University of Western Australia, Perth, Australia (58)

Phenoxy herbicides such as 2,4-D, MCPA are important selective herbicides used extensively in agriculture for weed control. Wild radish (*Raphanus raphanistrum)* is a problem weed across the globe and heavily infests crop fields in Australia. Phenoxy herbicides are used to selectively control dicot weeds including wild radish, and as a result of selection, phenoxy- resistant (R) wild radish biotypes evolved in Western Australia. The genetic basis of this resistance is unknown. The overall goal of this research was to determine the inheritance of wild radish phenoxy resistance through classical genetic approaches using phenoxy-R and -susceptible (S) wild radish biotypes. F_1 progeny were raised from crosses between homozygous MCPA-R and -S wild radish parental lines. The F_2 and backcross progeny were also raised and assessed for MCPA resistance or susceptibility. Analyses of the F_2 as well as backcross progeny suggest that a single dominant gene confers resistance to MCPA in wild radish. Understanding the genetic basis of herbicide resistance assists in assessing the spread of herbicide ressitant plants in a population and therby enables recommendation of prudent weed management practices.

INCREASING SAFLUFENACIL EFFICACY BY ALTERING SPRAY SOLUTION PH. Jared M. Roskamp*, William G. Johnson; Purdue University, West Lafayette, IN (59)

Saflufenacil solubility and efficacy has been shown to be influenced by carrier water pH. This research was conducted to determine if altering the pH of a solution already containing saflufenacil would influence the efficacy of the herbicide. Saflufenacil at 25 g ai ha^{-1} was mixed in carrier water with one of five initial pH levels (4.0, 5.2, 6.5, 7.7, or 9.0) and then buffered to one of four final solution pH levels (4.0, 6.5, 9.0, or none) and applied to field corn. All treatments included ammonium sulfate at 20.37 g L^{-1} and methylated seed oil at 1% v/v. Generally, saflufenacil with a final solution pH of 6.5 or higher reduced dry weight of corn plants more than saflufenacil applied in a final pH of 5.2 or lower. When applying saflufenacil in water with an initial pH of 4.0 or 5.2, efficacy was increased by raising the final solution pH to either 6.5 or 9.0. Conversely, reduction in corn dry weight was less when solution pH of saflufenacil mixed in carrier water with an initial pH of 6.5 or 7.7 was lowered to a final pH of 4.0. When co-applying saflufenacil with herbicides that are very acidic, such as glyphosate, efficacy of saflufenacil may be reduced if solution pH is 5.2 or lower.

ASSOCIATION OF EPSPS GENE AMPLIFICATION WITH GLYPHOSATE RESISTANCE IN WATERHEMP.

Laura A. Chatham*[1], Chance Riggins[1], Micheal D. Owen[2], Patrick Tranel[3]; [1]University of Illinois Urbana Champaign, Urbana, IL, [2]ISU, Ames, IA, [3]University of Illinois, Urbana, IL (60)

The widespread use of the herbicide glyphosate in U.S. agriculture imposes great selective pressure on weed populations to evolve resistance. In Palmer amaranth (*Amaranthus palmeri*) the mechanism of resistance was shown to be amplification of the glyphosate target site gene 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). Preliminary studies suggest gene amplification may be a mechanism of glyphosate resistance in waterhemp (*Amaranthus tuberculatus*) as well. The objective of this research was to further investigate the relationship between EPSPS copy number and glyphosate resistance in waterhemp. Field studies were conducted in Illinois and Iowa, where plots were sprayed with 2x, 4x and 8x rates of glyphosate (1x = 840 g ae/ha). Survivors from each plot were selected for relative EPSPS copy number analysis via quantitative PCR. Plots treated with glyphosate had significantly higher percentages of survivors with high relative EPSPS copy number (>2.5 fold change) compared to control plots ($P<0.0001$). However, among glyphosate-treated plots, no significant increase in average EPSPS copy number was observed with increased glyphosate rate. Furthermore, though copy number analysis indicated that approximately half the population had elevated copy number, visual ratings of the plots before and after indicated that only about 5% of plants survived glyphosate treatment. In a parallel study, waterhemp populations from several Illinois counties were screened with a 1.5x rate of glyphosate in the greenhouse. Sensitive and resistant plants were selected for EPSPS copy number analysis. Overall, resistant populations showed elevated EPSPS copy number while sensitive populations did not. However, several sensitive plants with high copy number and several resistant plants without elevated copy number were observed. This contradiction supports what we found in the field and indicates that elevated copy number may not be singly responsible for conferring resistance in these populations. Our results indicate that gene amplification is associated with glyphosate resistance in waterhemp, but further research is necessary to completely understand the mechanism of resistance.

INVESTIGATING THE VACUOLE PUMP IN GLYPHOSATE-RESISTANT HORSEWEED WITH ^{31}P NMR.

Xia Ge*[1], Dana A. d'Avignon[1], Elizabeth Ostrander[2], Joseph J. Ackerman[1], Doug Sammons[3]; [1]Washington University in St Louis, St Louis, MO, [2]Monsanto, St Louis, MO, [3]Monsanto, St. Louis, MO (61)

Non-target site glyphosate resistance (GR) mechanism(s) play an important role in GR weedy species that have evolved over the past two decades. Understanding GR mechanisms at the cellular level is critical to establishing methods to control GR weeds and to sustain associated weed management agricultural practices. Our lab previously reported ^{31}P NMR studies of glyphosate in plants that demonstrated uptake into the cell is an active process and, further, that rapid vacuole sequestration is the dominate resistance mechanism in both GR horseweed and GR ryegrass species. The phenomenon of vacuole sequestration infers the presence of a tonoplast transmembrane glyphosate pump in GR plants. In this report, we present additional studies on the GR horseweed tonoplast pump including its: (i) functional dependence upon ATP, (ii) ability to pump other substrates, and (iii) response to competition from other substrates. These data suggest that the GR tonoplast pump behaves similarly to multi-drug resistant pumps found in bacteria or in mammalian cancer cells. The GR horseweed pump shows all of the characteristics associated with ATP-binding cassette (ABC) transporters. This report presents an improved understanding of glyphosate (and potentially other herbicides) entry into the plant cell and its compartmentation and translocation following entry.

REDUCED TRANSLOCATION IS ASSOCIATED WITH COMMON LAMBSQUARTERS TOLERANCE TO GLYPHOSATE.

Melinda K. Yerka[1], Andrew Wiersma[2], Bradley Lindenmayer[3], Philip Westra[3], Natalia de Leon[1], David E. Stoltenberg*[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Colorado State University, Ft. Collins, CO, [3]Colorado State University, Fort Collins, CO (62)

Common lambsquarters tolerance to glyphosate is problematic due its widespread distribution, competitive ability with many crop species, the widespread use of glyphosate in agriculture, and the potential to develop decreased sensitivity to multiple herbicide modes of action. The mechanism by which common lambsquarters tolerance to glyphosate occurs has not been identified. Therefore, we conducted experiments to determine the mechanism of tolerance to glyphosate in an accession of common lambsquarters from Indiana relative to a sensitive accession from Wisconsin. The ED_{50} value (the effective dose that reduced shoot mass 50% relative to non-treated plants) for the tolerant accession (1.6 kg ae ha^{-1} ± 0.4 SEM) was 8-fold greater than for the sensitive accession (0.2 kg ae ha^{-1} ± 0.2 SEM) 28 d after treatment. The glyphosate target site (*5*-enolpyruvylshikimate-*3*-phosphate synthase, EPSPS) DNA sequence at proline 106, shikimate accumulation as an estimate of EPSPS sensitivity, and EPSPS protein expression did not differ between accessions. Absorption of ^{14}C-glyphosate was slightly greater in the tolerant accession than in the susceptible accession at 48- and 72-h after treatment. However, the tolerant accession translocated a smaller percent of absorbed ^{14}C-glyphosate to the shoot apical meristem 24-, 48-, and 72-h after treatment ($P \leq 0.05$, 0.01, and 0.10, respectively), consistent with an altered translocation mechanism observed in several other glyphosate-resistant species.

APPLICATIONS OF SHIKIMATE COUPLED ASSAY FOR FIELD AND LABORATORY. Keith Kretzmer*[1], Doug Sammons[2], Dale Shaner[3], David Rumecal[4], Robert DeJarnette[5]; [1]Monsanto Company, St Louid, MO, [2]Monsanto, St. Louis, MO, [3]USDA, Fort Collins, CO, [4]USDA, St Louis, MO, [5]Monsanto, St Louis, MO (63)

A shikimate assay has been developed for accurate, simple and high throughput quantification of shikimic acid using a coupled enzymatic assay. This assay detects the presence of shikimic acid in plant extracts and whole plant tissues and is especially useful for assays of glyphosate sensitive plant tissues.

FITNESS OF GLYPHOSATE RESISTANT GIANT RAGWEED (*AMBROSIA TRIFIDA* L.). Kabelo Segobye*, Burkhard Schulz, William G. Johnson, Stephen C. Weller; Purdue University, West Lafayette, IN (64)

Giant ragweed (*Ambrosia trifida L.*) is a competitive annual plant found in disturbed landscapes and is an important weed in Indiana and the US Corn Belt. It is one of the most common and problematic weeds in corn and soybean production. The introduction of glyphosate resistant agronomic crops ("Roundup®-Ready") in 1996 provided a new tool to manage giant ragweed. However, the use of glyphosate drastically increased after 1996 which led to overreliance and repeated use of glyphosate for weed control in roundup ready cropping systems. These use patterns resulted in tremendous selection pressure for evolution of glyphosate resistant weeds and specifically giant ragweed. Our research is investigating the mechanism (s) of resistance to glyphosate and the fitness of glyphosate resistant giant ragweed. We hypothesize that the basis of resistance in the Indiana giant ragweed biotype is related to reduced translocation of glyphosate and this resistance leads to a fitness loss in the resistant biotype. Our research involves a direct comparison between glyphosate sensitive (GS) and glyphosate resistant (GR) giant ragweed. Experiments were designed to determine any fitness cost associated with glyphosate resistance trait. Research compared growth of the GS and GR biotypes when growing independently of each other and in competition studies under field conditions in the absence of glyphosate. The two biotypes were also compared for response to glyphosate at 1X, 2X, 4X and 8 X application rates (1X=0.84kg/ha). Results show that when plants were grown independently, the GS plants grow taller than GR plants. However, no differences occur in leaf area, leaf fresh or dry weight, seed production and total plant fresh and dry weight. Competition studies show that GS plants were more competitive than GR plants in terms of total dry weight and productivity. GR plants had a unique response when treated with glyphosate, exhibiting initial rapid necrosis of mature leaves within 12 hours of treatment. GR plants do not die from a glyphosate treatment but resume normal-growth from axillary meristems and reproduce. The progression of the response and symptoms resemble a typical hypersensitive response similar to that observed on some plants after pathogen attack. GS plants do not exhibit rapid leaf necrosis but their leaves become chlorotic, then necrotic and plants die over a 2 to 3 week period. Results show that GR plants will persist in our current cropping systems if glyphosate continues to be the main weed control tool.

COMPARISON OF DUPONT'S TRANSGENIC HERBICIDE TOLERANT CANOLA AND CONVENTIONAL HERBICIDE RESISTANT CANOLA OUT-CROSSING RATES. Tim J. Johnson*; Pioneer, Ankeny, IA (65)

A common requirement for regulators is the establishment of equivalency between the GE-plant and its non-genetically modified (non-GE) counterpart. Standard agronomic measurements such as plant height, flowering and yield are used to make these equivalency comparisons; however, for certain crops some regulatory bodies also require additional phenotypic measures such as out-crossing rate comparisons. The objective of this study was to directly compare the out-crossing rate between GE and non-GE canola lines. DuPont Pioneer's GE canola with herbicide tolerance to glyphosate was compared to a non-GE canola line tolerant to acetolactate synthase (ALS) inhibiting herbicides. The glyphosate-tolerant canola was derived from gene transformation and is not tolerant to ALS inhibiting herbicides. The ALS herbicide-tolerant canola was developed by conventional breeding practices and is not tolerant to glyphosate. Each treatment was replicated three times in a randomized complete block design spatially isolated from one another.

The experimental donors, either glyphosate or ALS-tolerant canola, were planted in a central square located in the middle of a larger square plot planted with an herbicide intolerant, male-fertile recipient canola. Seed samples were taken from recipient plots at several distances radiating out in four directions from the donor section. Outcrossing rates were evaluated by collecting the resultant recipient seed at specific distances (0.5. 1.0 and 5.0 m) and directions (East, West, North and South) away from the donor. The seed was planted and the plants produced subjected to relevant herbicide sprays. The herbicide spray was used to determine the amount of seed produced from donor pollination as opposed to seed produced by pollination from the recipient plants themselves. Statistical analysis used the linear mixed model approach. The Residual Maximum Likelihood estimation procedure was utilized to generate estimates of variance components and entry means. The statistical comparison was conducted by testing for difference in Least Square Means (LS-Means) between the GE and non-GE canola at each sampled distance and direction. The outcrossing rate of the GE canola showed no statistically significant difference compared to the outcrossing rate of conventional canola, indicating GE canola is equivalent to conventional canola in its outcrossing potential.

FINE TUNING MICRORATES FOR EARLY SEASON BROADLEAF WEED CONTROL IN ONION. Collin Auwarter*[1], Harlene M. Hatterman-Valenti[2]; [1]NDSU, Fargo, ND, [2]North Dakota State University, Fargo, ND (66)

Field research was conducted at the Oakes Irrigation research center near Oakes, ND to refine microrate applications using bromoxynil and oxyfluorfen for early season broadleaf control in 'Sedona' onion. Clethodim plus a petroleum oil-surfactant, Herbimax, was added to each application at a rate of 0.03 lb/A and 1 pt/A, respectively. Conventional PRE treatments using ethofumesate at 1 and 2 lb/A and DCPA at 13.33 lb/A were also incorporated into the trial. Onions were planted May 14 and harvested October 3. Herbicide applications were made May 22 (PRE-A), June 4 (flag leaf-B), June 12 (1.5 leaf-C), June 21 (2 leaf-D), June 27, (3 leaf-E), and July 2 (4 leaf-F) using a CO_2 pressurized sprayer equipped with 80º flat fan nozzles with a spray volume of 20 GPA and pressure of 40 psi. Treatments that included bromoxynil during at least one of the application timings provided better common lambsquarters control throughout the trial compared to treatments without bromoxynil. In contrast, the treatment with oxyfluorfen applied alone had poor common lambsquarters control. However, applying bromoxynil at the 0.0625 lb/A followed by tank mixes of bromoxynil and oxyfluorfen at 0.0625 lb/A provided the best common lambsquarters control compared to all other treatments. Applying bromoxynil at the 0.031 lb/A followed by tank mixes of bromoxynil and oxyfluorfen at the 0.0625 lb/A had significantly less control of common lambsquarters. The highest yielding treatment was when bromoxynil was applied at 0.0625 lb/A followed by tank mixes of bromoxynil and oxyfluorfen at 0.0625 lb/A with 655 CWT/A. The lowest yielding treatment besides the untreated, which didn't produce anything, was when bromoxynil was applied at 0.031 lb/A followed by tank mixes of bromoxynil and oxyfluorfen at 0.0625 lb/A with 213 CWT/A. The preemergence conventional treatment of ethofumesate at 1 lb/A had the second highest yield of 562 CWT/A.

BENEFITS AND DRAWBACKS OF ADDING PRE APPLICATIONS OF FOMESAFEN TO EXISTING HERBICIDE TREATMENTS FOR WEED CONTROL IN VINE CROPS. Darren E. Robinson*, Dave Bilyea; University of Guelph, Ridgetown, ON (67)

The objective of this study was to determine the effect of adding fomesafen to preemergence (PRE) tank-mixtures of clomazone + s-metolachlor, clomazone + halosulfuron and s-metolachlor + halosulfuron on weed control and tolerance of cucumber, pumpkin and squash. These trials were conducted at the University of Guelph, Ridgetown Campus, on Watford-Brady loam (5.5% organic matter [OM]) and sandy loam (3.7% OM) soils, in 2011 and 2012, respectively. There were no treatment by year interactions, so we were able to combine data over the two years of the study. The addition of fomesafen to PRE tank-mixtures of clomazone + s-metolachlor, clomazone + halosulfuron and s-metolachlor + halosulfuron improved control of common lambsquarters and common ragweed by 15 to 20%. The addition of fomesafen to the three PRE tank-mixtures did not improve control of large crabgrass or green foxtail. The tolerance of cucumber, pumpkin and squash to tank mixtures of clomazone + s-metolachlor, clomazone + halosulfuron and s-metolachlor + halosulfuron were similar. Some temporary bleaching (less than 10% injury) was observed in all treatments that contained clomazone, and some chlorosis was observed in the treatments that contained halosulfuron (less than 5% injury); however all three vine crop species outgrew the injury, and marketable yield was unaffected. The addition of fomesafen to the tank-mixture of clomazone + s-metolochlor caused injury and reduced yield of cucumber. Meanwhile, the addition of fomesafen to the tank-mixture of s-metoachlor + halosulfuron caused injury and reduced yield of all three vine crops. Depending on the tank mixture, the benefits of improved weed control that were obtained by adding fomesafen may be outweighed by injury and crop yield loss.

TOLERANCE OF VARIOUS LANDSCAPE ORNAMENTALS TO POSTEMERGENCE APPLICATIONS OF AMICARBAZONE AND FLUCARBAZONE. Tyler Campbell*[1], James Brosnan[1], Jose J. Vargas[2]; [1]University of Tennessee, Knoxville, TN, [2]The University of Tennessee, Knoxville, TN (68)

The photosystem II inhibitor amicarbazone and the acetolactate synthase inhibitor flucarbazone are being evaluated for weed control in turf and ornamentals. In 2012, tolerance of ten ornamental species was evaluated following applications of amicarbazone, flucarbazone, and bentazon. Ornamental species included: rose-of-sharon (Hibiscus syriacus), wintercreeper euonymus (Euonymus fortunei), 'Lynwood Gold' forsythia (Forsythia x intermedia), 'Knockout' rose (Rosa sp.), 'Natchez' crape myrtle (Lagerstroemia indica x L. faurei), autumn olive (Eleagnus umbellata), Virginia sweetspire (Itea virginica), buttonbush (Cephalanthus occidentalis), 'Flore-Pleno' fuzzy deutzia (Deutzia scabra), and Chinese dogwood (Cornus kousa). Rooted cuttings were grown for six weeks in 3.8 L containers filled with 100% aged pine bark before being transplanted into in-ground field plots on 18 June 2012. Soil series of the field plots was a Sequatchie silt loam. Plant heights at transplanting were as follows: rose-of-sharon (8 to 25 cm), wintercreeper (10 to 28 cm), forsythia (10 to 28 cm), rose (15 to 20 cm), crape myrtle (15 cm), autumn olive (30 cm), Virginia sweetspire (38 to 61 cm), buttonbush (51 to 91 cm), deutzia (61 to 91 cm), and Chinese dogwood (51 to 91 cm). Treatments were arranged in a randomized complete block design with three replications and applied to plots (3 x 15 m) containing species planted on a 1.5 m spacing. Treatments included post-directed applications of amicarbazone (49.5 and 446 g ha-1), flucarbazone (29 and 88 g ha-1), and bentazon (1120 g ha-1). Over-the-top (OT) applications of amicarbazone (980 g ha -1) and flucarbazone (29 g ha-1) were also evaluated. Flucarbazone treatments included a non-ionic surfactant at 0.25% v/v. All treatments were applied on 28 June 2012 using a CO2 powered boom sprayer calibrated to deliver 23 gpa using a 6504E nozzle at 60 psi. Both post-directed and over-the-top applications were made with this equipment. Ornamental injury was evaluated 14, 28 and 42 days after treatment (DAT) on a 0 (i.e., no injury) to 100% (i.e., complete plant death) scale relative to an untreated check. Ornamental injury was greatest 28 DAT and ranged from 2 to 18% for post-directed applications. Over-the-top applications of amicarbazone and flucarbazone were more injurious than those applied post-directed with injury ranging from 25 to 67% at 28 DAT. By 42 DAT, recovery was apparent as injury only ranged from 0 to 13% across all species regardless of application method.

LONG-TERM YELLOW TOADFLAX CONTROL IN RANGELAND WITH AMINOCYCLOPYRACHLOR. Brian M. Jenks*, Tiffany D. Walter; North Dakota State University, Minot, ND (69)

Yellow toadflax (Linaria vulgaris P. Mill.) has spread over hundreds of acres of rangeland in western North Dakota that were previously infested with leafy spurge. Leafy spurge was controlled 10-20 years ago through biological and chemical means. Given less competition, yellow toadflax has now replaced one yellow-flowered noxious weed with another. The objective of this study was to evaluate DPX-MAT28 (aminocyclopyrachlor) for yellow toadflax control in rangeland compared to picloram. DPX-MAT28 is an experimental herbicide being developed by DuPont for weed control in rangeland, pasture, and non-cropland areas. Treatments were applied to 10 by 30 ft plots with a hand boom using standard small plot procedures. Treatments were applied at the vegetative stage (Jul 25), flowering stage (Sep 11), and in late fall (Oct 16) of 2008. No other treatments have been applied. The treatments were evaluated for percent visual control in 2009, 2010, 2011, and 2012. Weed density was recorded prior to application in 2008 and each year after. Picloram (2 pt/A) provided 23-60% yellow toadflax visual control in 2009, but decreased to 0-3% in 2012. Picloram reduced toadflax density 6-55% in 2009, but density gradually increased in 2010, 2011, and 2012. DPX-MAT28 at 1.5 oz ai/A provided 90-95% yellow toadflax visual control in 2009, but decreased to 22-32% in 2012. Toadflax density was reduced 84-98% in 2009; however, density increased from 0.2-1.0 plants/ft^2 in 2009 to 4.6-6.9 plants/ft^2 in 2012. DPX-MAT28 at 3 oz ai/A provided 98-100% visual control and reduced density 100% in 2009 and 2010. Plants began to appear again in 2011 with 0-0.3 plants/ft^2, and increased to 0-1.8 plants/ft^2 in 2012. DPX-MAT28 at 2 oz ai/A tank mixed with chlorsulfuron at 0.75 oz ai/A provided 99-100% yellow toadflax visual control in 2009, but decreased to 69-84% in 2012. Toadflax density was reduced 99% in 2009; however, density increased from 0-0.1 plants/ft^2 in 2009 to 0.6-1.8 plants/ft^2 in 2012. Grass injury from all treatments was 6% or less in 2009, but no visual injury was observed in 2010-2012.

REPRODUCTIVE POTENTIAL OF SUMMER ANNUAL WEEDS BASED ON TERMINATION METHOD AND TIMING. Erin C. Taylor-Hill*, Karen A. Renner, Christy Sprague; Michigan State University, East Lansing, MI (71)

Seed production by escaped weeds is a major concern in both conventional and organic farming systems. Each weed that escapes control practices produces hundreds to thousands of seeds that will emerge over several growing seasons. Currently information is lacking on when seeds become viable during plant development and if there are specific late-season management strategies to reduce viable seed formation. The objectives of this research were to determine: 1) the reproductive growth stage at which terminated summer annual weeds will produce viable seeds and 2) if termination methods alter the time of viable seed formation. Velvetleaf, jimsonweed, Canada thistle, and giant foxtail were terminated at three different reproductive stages: flowering, the onset of immature seed, and the presence of mature seed. Due to the rapid development of immature seeds, common lambsquarters was only terminated at the onset of immature seed and at seed maturity. Three termination methods were examined: cutting at the base of the plant (simulating hand hoeing), chopping the whole plant into 10 cm segments (simulating mowing), and applying glyphosate (2% v/v solution). The experiment was conducted in two years with six replications of each treatment. Following termination plants were either stored in mesh bags lying between rows of a soybean field (cut and chop) or were staked, bagged and allowed to remain standing for 3 weeks or more (glyphosate application). Bags were retrieved in early November of each year and intact, full seeds were counted and tested for viability. A subset of seeds was overwintered and tested for viability in March. In 2011, plants terminated at flowering did not produce seed, regardless of termination method. The only exception was flowering foxtail, for which we observed 12 viable seeds or less formed when terminated using glyphosate. All weeds studied produced some viable seed when terminated at the onset of immature seed, regardless of termination method. However, the resulting seed was only 0.5 to 34% of total seed numbers observed when plants were allowed to produce some level of mature seed prior to termination. Differences among termination methods were observed for mature Canada thistle plants (cutting reduced viable seed production) and immature and mature giant foxtail plants (glyphosate reduced viable seed production). Overwintering did not significantly reduce seed viability of any species. Results of the summer of 2012 experiment will be included in the presentation.

FITNESS OF SORGHUM, SHATTERCANE AND THEIR F2 HYBRID. Jared J. Schmidt*[1], Scott E. Sattler[2], Aaron J. Lorenz[3], Jeff F. Pedersen[4], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]USDA-ARS, University of Nebraska-Lincoln, Lincoln, NE, [3]University on Nebraska-Lincoln, Lincoln, NE, [4]USDA-ARS; University of Nebraska-Lincoln, Lincoln, NE (72)

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 a similar fitness with respect to leaf area, production, and biomass. 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 this experiment was to determine growth and fitness characteristics of the F2 progeny of the shattercane x sorghum hybridization. The experiment was conducted at the University of Nebraska South Central Ag. Laboratory near Clay Center, NE. In the fall of 2011, 20 panicles from a shattercane population were collected from a corn field near Arapahoe, NE. A sample of these seeds was grown in the greenhouse and hand emasculated before flowering. Sorghum pollen was introduced to the emasculated flowers and they were allowed to mature on the panicle. 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 a F2 population. A similar quantity of seeds from each of the panicles was combined to form a representative sample. 50 seeds from the F2 population, the sorghum parent, and the shattercane parent were sewn in the summer of 2012 in 3.05m rows. Emergence and plant height were tracked weekly and biomass and leaf area were measured at anthesis. Upon maturation the seeds from each panicle were collected. Number of seeds per panicle and seed weight was measured. Emergence of the F2 was slightly delayed in comparison to the sorghum and shattercane. This might suggest that the F2 seeds were exhibiting dormancy (an important weedy characteristic) at the time of planting.

CROP CANOPY EFFECTS ON KOCHIA SEED PRODUCTION. Rutendo P. Nyamusamba*, Mike J. Moechnig, David A. Vos, Jill K. Alms, Darrell L. Deneke; South Dakota State University, Brookings, SD (73)

Kochia (*Kochia scoparia*) is becoming more difficult to manage in central South Dakota as biotypes resistant to glyphosate and ALS-inhibiting herbicides are becoming more common. Previous research has indicated kochia seed lacks dormancy mechanisms which could enable seed bank depletion if kochia populations are managed aggressively. Consequently, the objective of this study was to quantify the effects of different crop canopies on kochia seed production in order to develop integrated weed management recommendations that account for crop competition. In 2010, 2011 and 2012 corn, soybeans, field peas, wheat and fallow field plots (each 6 m by 15 m) were established in Brookings SD and replicated four times. Two kochia cohorts, each consisting of 100 seeds in 0.3 by 0.3 m subplots, were planted at the time of crop planting and approximately 28 days after crop planting. In addition, three single kochia plants, evenly spaced (100cm), were established from seed in each plot. Kochia germination and survival were quantified from the cohorts. Biomass and seed production were quantified for each of the single-kochia plants at crop harvest. Kochia germination was inconsistent among the crop treatments. Generally, crop canopies did not influence kochia germination and survival but planting time affected both germination and survival of kochia. Overall kochia survival mean counts for the 1st planting in 2010 and 2011 were about 49% and 68% respectively. Differences were evident in 2012 with LSD test grouping showing that field pea had the lowest mean. The Dunnette's test also showed differences between only field pea and the control in 2012. In general, kochia survival appeared to be greatly reduced ($P<0.05$) when it emerged later in the season. For the first kochia planting, seed counts per kochia plant averaged 26000, 312, 134, 104 and 46 in fallow, soybeans, wheat, corn and field peas respectively in 2011. In the second planting, the single kochia plants did not grow enough to produce seed with an average height of 5mm. Relative to the fallow treatment, all crop canopies reduced ($P<0.05$) kochia biomass and seed production by more than 90%. Kochia biomass production was positively correlated with seed count per plant (Kochia seed count = [510.08 x kochia biomass] – 458.93 with $R^2 = 0.98$). The magnitude of kochia shoot and seed reduction was similar among the different crop canopies. Additional research is needed to determine if the combined effects of crop competition and aggressive kochia management could deplete kochia seed banks.

CROP CANOPY EFFECTS ON *KOCHIA SCOPARIA* IN KANSAS. Andrew Esser*; Kansas State University, Manhattan, KS (74)

A better understanding of kochia (*Kochia scoparia*) seed dynamics is necessary for long term management of this increasingly troublesome weed. It has become more abundant during recent hot and dry periods due to its competitive characteristics of early germination at low soil temperatures, rapid growth, and tolerance to heat, drought and saline soils. Research has been conducted to evaluate kochia seed dynamics in the soil, but there is little information available regarding seed characteristics produced within varying crop canopies. The objective of this research was to evaluate maternal environmental effects on kochia growth and seed production and document its variability in dormancy and viability of seed produced within a single kochia plant. A greenhouse experiment was conducted with two kochia seed populations from Hays, KS. Cropland and non-cropland populations were grown and limited to self-pollination. Mature plants were divided into three equal parts (top, middle and bottom). Seeds were harvested from each section and a germination study was conducted with 50 seeds per plant section per petri dish with 10 mL water. Petri dishes were placed in a growth chamber with 12 h light: 12 h dark at a temperature of 20:10 C and germination counts were taken for six weeks. In general, plants that flowered first in the greenhouse had seed that germinated quickly with little difference in placement on the plant, while later flowering plants had seed that germinated more slowly. 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 five different crop canopies 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. Plant heights of kochia and crop were taken weekly for the duration of the summer. Kochia height was tallest when grown with corn compared to the other crop canopies. Average kochia heights by the end of the season ranged from 33 to 95 cm across the varying crop canopies. Based on these preliminary observations, there is variability in kochia seed with regards to performance in different crop canopies.

DUPONT'S PERSPECTIVES ON MANAGING WEED RESISTANCE IN NORTH CENTRAL STATES. David Saunders*[1], Larry H. Hageman[2], Helen A. Flanigan[3]; [1]DuPont Crop Protection, Johnston, IA, [2]DuPont Crop Protection, ROCHELLE, IL, [3]DuPont, Greenwood, IN (75)

Since the 1990's there have been 3 successive waves of new tools brought to the marketplace that have fundamentally changed weed control in row crops – the ALS herbicides, glyphosate tolerance, and most recently, auxin tolerance traits. Each new tool brought or is anticipated to bring expectations for significant improvement in efficacy against troublesome weeds while at the same time lowering costs and simplifying management practices. Early adopters of ALS herbicides, such as imazethapyr in soybeans, saw their expectations for improved efficacy versus older established herbicides met or exceeded. Initial good product performance lead to over-simplified product use patterns, questionable crop rotational practices, and intense selection pressure for weeds resistant to ALS herbicides. The same pattern of over-use, over-simplification, and resulting weed resistance was repeated with the advent of glyphosate-tolerant crops and is poised to repeat itself yet again with the auxin tolerance technologies. Questions arise on how best to encourage product use patterns that extend the useful life of new technologies in spite of the fact that excellent initial effectiveness, reasonable cost, and simplicity will likely drive use patterns that promote short-term effectiveness. It is important to recognize that a company's product portfolio will likely contain a range of herbicide products designed for use with new technologies that are appropriate for addressing a wide range of field needs. Different products and use patterns may be appropriate for well-managed fields with routine weed control needs, fields containing "at-risk" weeds where the potential for resistance exists but where no immediate threat has been identified, or "high-risk" fields where resistance is an established problem that must be addressed. DuPont Crop Protection believes key considerations for driving sustainable product use patterns include; designing single and multiple active ingredient products with efficacious use rates and realistic performance claims, pricing and servicing products so favorable behavior is incentivized and irresponsible use is penalized, and promoting and positioning products to meet specific field needs.

SHOULD ATRAZINE AT REDUCED RATES BE APPLIED PRE OR POST IN TANK-MIX COMBINATIONS TO IMPROVE GIANT RAGWEED CONTROL IN CORN? Ross A. Recker*[1], Vince M. Davis[2]; [1]Univeristy of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI (76)

Giant ragweed (*Ambrosia trifida* L.) is currently the only confirmed glyphosate-resistant weed in Wisconsin. Atrazine is often used at reduced rates in Wisconsin to decrease its environmental impact. Atrazine is an effective broadleaf herbicide to help provide control of giant ragweed in corn. The objective of this research is to determine if reduced rates of atrazine should be applied preemergence (PRE) or postemergence (POST) to improve giant ragweed control and herbicide resistance management strategies in corn. Field experiments were conducted near Janesville, WI and Sauk City, WI in 2012. Atrazine was applied PRE or POST at a rate of 0, 0.56, or 1.12 kg ai ha^{-1} in combination with three possible POST herbicide programs: glyphosate, glufosinate, or tembotrione. A PRE application of *S*-metolachlor was made across the whole trial to control grass weeds. Giant ragweed control was estimated visually at 10 days after PRE application, prior to POST application, 10, 21, and 35 days after the POST application, and prior to harvest using a scale ranging from 0 to 100, with 100 representing complete giant ragweed control. Giant ragweed heights and population densities were measured prior to POST application, at corn canopy, and prior to corn harvest. Giant ragweed biomass was collected prior to corn harvest. Corn yields were adjusted to 15.5% moisture. Giant ragweed presence was highly variable at the Janesville location. Therefore, results were not combined across locations and only data from Sauk City are discussed. Rainfall during the growing season was below normal in 2012. The Sauk City location received 4.4 cm of total rainfall from planting (May 11) until corn closed the canopy (July 13), and 26.0 cm between complete corn canopy and corn harvest (October 31). Prior to the POST application timing, giant ragweed densities were not influenced by the different rates of atrazine applied PRE. However, giant ragweed biomass was significantly reduced from atrazine applied POST (38.6 kg ha^{-1}) versus PRE (99.6 kg ha^{-1}), ($P = 0.0025$). Additionally, giant ragweed efficacy ratings taken visually, one month before harvest, were slightly higher for atrazine applied POST (98%) versus PRE (96%) ($P = 0.0438$). Corn yields did not show a significant difference between PRE and POST application of atrazine. Corn yields were higher for all treatments that included atrazine versus treatments that did not include atrazine (11,130 kg ha^{-1} versus 10,360 kg ha^{-1}, respectively) ($P = 0.0149$). From 2012 results we conclude that atrazine helped control giant ragweed and improved corn yield as part of a herbicide program, even at reduced rates. Based on similar giant ragweed densities at POST timing regardless of PRE atrazine rates, applying atrazine at the POST timing might be a better herbicide resistance management strategy when reduced rates are used. Field experiments will be repeated in 2013.

GYLPHOSATE-RESISTANT GIANT RAGWEED CONTROL WITH SAFLUFENACIL AND DICAMBA. Stevan Z. Knezevic*[1], Dejan Nedeljkovic[2], Jon E. Scott[1], Avishek Datta[3], Neha Rana[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Belgrade, Belgrade, Serbia, [3]Asian Institute of Technology, Bangkok, Thailand (77)

With the widespread adoption of glyphosate tolerant crops and repeated use of glyphosate for weed control in the last 15 years, 21 weed species have developed glyphosate resistance worldwide. Glyphosate resistant (GR) giant ragweed biotypes have been reported from 11 states in U.S. including Nebraska. Field experiments were conducted in 2012 in David City, NE to evaluate control of glyphosate-resistant giant ragweed with alternative herbicides. Dose response studies were described for glyphosate at the label rate (1060 g ai/ha) tankmixed with four saflufenacil doses (0, 0.5X, 1X, 2X, and 4X) and four doses of dicamba (0, 1X, 2X, 4X, and 8X) applied early postemergence at two application timings (10 and 20 cm). Visual weed control was estimated 7, 14, and 21 DAT, and weed dry matter was recorded. Based on the visual ratings and dry matter reduction, dose response curves were determined for control of 10 and 20 cm tall GR giant ragweed and ED_{80} and ED_{90} values were described. Glyphosate+saflufenacil failed to provide complete control of GR giant ragweed at 21 DAT. However, the ED_{90} values for glyphosate (1060 g ai/ha)+dicamba at 21 DAT for control of 10 cm and 20 cm tall giant ragweed were 214 and 402 g ai/ha, respectively, indicating that at both application timings glyphosate+dicamba provided good control of GR giant ragweed at the suggested label rates.

GIANT RAGWEED RESISTANCE TO GLYPHOSATE IN NEBRASKA. Stevan Z. Knezevic*[1], Dejan Nedeljkovic[2], Jon E. Scott[1], Avishek Datta[3], Neha Rana[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Belgrade, Belgrade, Serbia, [3]Asian Institute of Technology, Bangkok, Thailand (78)

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 initiated in 2012 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 were not significant, therefore data were combined over experimental runs. 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 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.

GIANT RAGWEED RESISTANCE TO GLYPHOSATE IN WISCONSIN. Courtney E. Glettner*[1], Melinda K. Yerka[1], James K. Stute[2], Timothy L. Trower[1], David E. Stoltenberg[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Janesville, WI (79)

Giant ragweed (*Ambrosia trifida*) is one of the most persistent and troublesome weed species in Midwestern row cropping systems. Contributing to the difficulty of managing giant ragweed is evolved resistance to herbicides, including glyphosate, which has been confirmed in several Midwest states. Furthermore, giant ragweed multiple resistance to glyphosate and acetolactate synthase (ALS) inhibitors has been confirmed in Minnesota and Ohio. In Wisconsin, three giant ragweed populations with putative resistance to glyphosate have been identified. To confirm and quantify resistance, seeds were collected from putative glyphosate-resistant and -susceptible plants in grower fields located in south-central (Columbia County), south-west (Grant County), and south-east (Rock County) Wisconsin. Seed samples were cleaned and subsamples were placed in nylon-mesh bags, buried in saturated sand, and maintained at 4-5 C for 8-12 wk to break dormancy. Whole-plant dose-response experiments were conducted under greenhouse conditions at the University of Wisconsin-Madison. Four- to six-node plants were treated with glyphosate doses ranging up to 16.8 kg ae ha^{-1}, including a non-treated check, or cloransulam-methyl at doses ranging up to 176.5 g ai ha^{-1}, including a non-treated check. Glyphosate treatments included 2.8 kg ha^{-1} ammonium sulfate (AMS). Cloransulam-methyl treatments included 0.25% (vol:vol) non-ionic surfactant and 2.24 kg ha^{-1} AMS. Treatments were applied in a stationary pot sprayer equipped with a flat-fan spray nozzle calibrated to deliver 187 L ha^{-1} spray solution at the level of the plant canopy. Shoot dry mass was measured 28 d after treatment. Each treatment was replicated six times, and experiments were repeated. Dose-response analysis indicated that the glyphosate ED_{50} value (the effective dose that reduced shoot mass 50% relative to non-treated plants) for the putative-resistant accession from Rock County (0.787 kg ae ha^{-1}) was 9.3-fold greater than for the susceptible accession (0.085 kg ae ha^{-1}) 28 d after treatment. The glyphosate ED_{50} values for the Grant County and Columbia County giant ragweed did not differ between putative-resistant and susceptible accessions. None of the accessions showed resistance to cloransulam-methyl. In vivo shikimate bioassays were conducted on three- to five-node greenhouse-grown plants to determine if the mechanism of resistance to glyphosate in the Rock County accession is associated with an altered enzyme target site (5-enolpyruvylshikimate-3-phosphate synthase, EPSPS). Preliminary results indicated less shikimate accumulation in leaf tissue of resistant plants than in susceptible plants at glyphosate doses ranging up to 1,200 µM. The EC_{50} value (the effective concentration of glyphosate that increased shikimate accumulation 50% relative to non-treated plant tissue) for the resistant accession (16.99 µM) was 6.0-fold greater than for the susceptible accession (2.85 µM) following 24 h of incubation under continuous light. These results suggest that resistance of the Rock County giant ragweed accession to glyphosate may be attributed to a less sensitive EPSPS target site; however, altered and/or reduced glyphosate translocation may also be a factor in the resistance response.

COMMON SUNFLOWER AND GIANT RAGWEED EMERGENCE PROFILES IN KANSAS.

Anita Dille*[1], Analiza H. Ramirez[2]; [1]Kansas State University, Manhattan, KS, [2]University of Florida, Lake Alfred, FL (80)

Emergence is an important process for weed establishment. Predicting weed emergence is essential in designing management strategies for effective weed control. An emergence study was conducted to characterize the emergence pattern of giant ragweed (*Ambrosia trifida*) and common sunflower (*Helianthus annuus*) populations that were found along roadsides and in agricultural and non-agricultural areas within KS. Ten and 16 populations of giant ragweed and common sunflower, respectively, were included in a common garden experiment conducted at the Department of Agronomy, Ashland Bottoms Research Center near Manhattan, KS. One hundred seeds of each population were sown on December 18, 2008. Emergence was observed weekly starting March of the following year. Data on total emergence for each population were analyzed using SAS and the relationship of percent cumulative emergence to GDD were analyzed using a logistic function with 0C as base temperature and with GDD accumulating from weeds' sowing date. Emergence pattern was characterized into start (GDD to 10% emergence), end (GDD to 90% emergence) and duration of emergence (GDD from 10 to 90%) by using predicted emergence curves. The emergence study revealed that both weed species emerged in mid-March and ceased to emerge by mid-May. Total seedling emergence for giant ragweed varied from 19% (±2.3) to 63% (±4.9) and common sunflower varied from 9% (± 1.3) to 59% (±10.2). Giant ragweed population from Hesston (AMBTR-8) had the most seedlings emerged while the populations from Topeka (AMBTR- 2) and Ottawa (AMBTR-3) had the least. For common sunflower, HELAN-3 collected near Blaine, KS and populations collected in 2004 (HELAN-1) and 2005 (HELAN-2) had the greatest and least emergence, respectively. Logistic curves described the cumulative emergence patterns of these populations and grouped giant ragweed into two distinct groups: AMBTR-A composed of 6 populations from varied environments while the second group (AMBTR-B) combined 3 populations that were collected from cropped areas and occurred throughout the field. AMBTR-A emerged early (330 GDD) and had longer duration of emergence (286 GDD) while AMBTR-B emerged late (410 GDD) but had shorter emergence duration (182 GDD). Four common sunflower groups were described based on start dates of emergence and durations but did not group according to where they occur within the state or the type of field where they were collected. HELAN-B (two populations) emerged earlier (299 GDD to 10% emergence) but finished emergence last (558 GDD to 90% emergence) and had the longest duration of emergence at 259 GDD. HELAN-A (2 populations) was the last to emerge (453 GDD to 10% emergence) but was the first to complete emergence (516 GDD to 90% emergence) and had the shortest duration of emergence at 63 GDD. HELAN-C (2 populations) and -D (remaining ten populations) were in between. The results of this study indicated that in KS, both giant ragweed and common sunflower emerged early enough to warrant control prior to and at planting.

RESPONSE OF GIANT RAGWEED BIOTYPES TO SOIL MICROBIAL PATHOGENS. Jessica R. Schafer*[1], Steven G. Hallett[2], William G. Johnson[2]; [1]Purdue Univeristy, West Lafayette, IN, [2]Purdue University, West Lafayette, IN (81)

Soil microorganisms have been shown to play an important role in the mode of action of the herbicide glyphosate. Many plant defense compounds essential for pathogen resistance are suppressed in a glyphosate-treated plant, allowing for the roots to be colonized by soil microbial pathogens. Root colonization by oomycete (e.g. *Pythium* spp. and *Phytophthora* spp.) and fungal organisms has been documented to increase after glyphosate treatment in a number of crop plants, yet this has not been investigated in weed species. The objective of this study was to investigate the susceptibility of glyphosate-resistant and glyphosate-susceptible biotypes of giant ragweed to soil microbial pathogens. Giant ragweed biotypes grown in sterile and unsterile field soil were treated with 0, 0.1, and 1.6 kg ae ha^{-1} of glyphosate. Five days after treatment, roots were sampled and plated onto selective fungal and oomycete medium, and the number of colonies per plate were counted and identified. As the glyphosate rate increased, the glyphosate-susceptible biotype grown in the unsterile soil was more susceptible to root colonization, compared to the glyphosate-resistant biotype grown in unsterile soil. Interestingly, the colonization by oomycete pathogens, predominantly *Pythium* spp., was also greater in the susceptible biotype grown in the unsterile soil when glyphosate was applied at the highest rate. An isolate of *Pythium* spp. from giant ragweed biotypes grown in unsterile field soil was identified as *Pythium aphanidermatum* and further pathogenicity test of this isolate are being conducted. This study revealed that the glyphosate-susceptible biotype of giant ragweed was more susceptible to *Pythium* spp., specifically *P. aphanidermatum*, than the glyphosate-resistant biotype following a glyphosate application. These data suggest that resistance to *Pythium* spp. may play a role in the mechanism of glyphosate resistance in giant ragweed.

EVALUATION OF A PUTATIVE HPPD-RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*) POPULATION IN NEBRASKA. Lowel Sandell*[1], Amit Jhala[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (82)

Palmer amaranth (*Amaranthus palmeri*) is a problematic broadleaf weed that commonly infests corn, soybean and sorghum fields in south central to south western Nebraska. In the fall of 2010, after consecutive years of control issues with HPPD-inhibiting herbicides, seed was collected from a putative HPPD-resistant Palmer amaranth population from Fillmore County Nebraska. Greenhouse dose response bioassays were initiated in 2011 and 2012 to determine the level of HPPD-resistance in this population. Two putative HPPD-susceptible Palmer amaranth populations were compared to the putative HPPD-resistant population. Two bioassays were conducted in greenhouses located at the University of Nebraska-Lincoln. The experimental unit was a 10x10x12 cm pot with a single Palmer amaranth plant. Applications were made when plants reached 10 cm. Twelve rates (0, 0.1x, 0.25x, 0.5x 0.75x, 1x, 1.5x, 2x, 3x, 4x, 6x, 12x) of mesotrione, tembotrione, topramezone and atrazine were applied in a 140 L ha^{-1} water carrier with the appropriate adjuvants in a spray chamber. Treatments were replicated eight times. Visual injury was recorded weekly until 21 DAT. Above ground biomass was harvested at 21 DAT, dried to a constant weight and recorded. Data from both runs of the study were combined for analysis. Dose response analysis, using the drc package in R, was performed to determine the ED_{80} and ED_{90} values for each population for each herbicide. The analysis showed a four to fourteen fold level of resistance depending upon the HPPD-inhibiting herbicide, based on visual injury ratings at the ED_{90} level. This population also has at least a ten-fold level of resistance to post emergence applied atrazine at the ED_{90} level. While levels of resistance to HPPD-inhibiting herbicides would not be considered high, labeled post emergence application rates are not adequate for satisfactory control. A diversified management approach should be used to achieve desired Palmer amaranth control and reduce hppd selection pressure.

GLYPHOSATE APPLICATIONS USING DIFFERENT RATES OF UAN AS A CARRIER. Turner J. Dorr*[1], Jeffrey Golus[2], Greg R. Kruger[3], Lowel Sandell[4], Mark L. Bernards[5], Stevan Z. Knezevic[6]; [1]University of Nebraska Lincoln WCREC, North Platte, NE, [2]University of Nebraska, Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]Western Illinois University, Macomb, IL, [6]University of Nebraska-Lincoln, Concord, NE (83)

Applications of herbicides and liquid fertilizers have been a common practice in agricultural fields for many years. The combination of the two products into one operation can save time and money; and increase efficiency of applicators and managers. However, fertilizer solutions can contain foreign materials including metals. Glyphosate in the spray solution could potentially bind to the metals and reduce efficacy of weed control with the application. A field study was conducted at two locations in Nebraska (Brule and North Platte) in 2010 to examine the effects of urea ammonium nitrate (32-0-0 UAN) as a carrier on efficacy of glyphosate at 0, 0.8, 1.6, 2.4, and 3.2 l ha^{-1}. Carriers included 100% water, 50% water / 50% UAN, and 100% UAN for each rate of glyphosate. The plot layout was in a split-block design with blocks being split on carrier composition. Treatments were applied with a tractor sprayer with a carrier volume of 141 l ha^{-1} for the 100% water and water/UAN carriers, and 282 l ha^{-1} for the UAN alone. No major differences were observed on control of kochia, horseweed and volunteer wheat using UAN as a carrier for glyphosate. Higher rates of glyphosate provided greater weed control. The results of this study suggest UAN can be used as a carrier for glyphosate without affecting efficacy of glyphosate on postemergence applications.

NITROGEN RATE AND THE EFFECT ON WESTERN CORN ROOTWORM EMERGENCE AND DAMAGE TO VOLUNTEER CORN. Paul T. Marquardt*, Christian Krupke, William G. Johnson; Purdue University, West Lafayette, IN (84)

Volunteer corn expressing herbicide resistance is a problematic weed. This issue is partially due to the increasing prevalence of stacking both herbicide and insect-resistant (mainly Bt) traits into the same genetically-modified plant. Previous research indicates that the Bt toxin concentrations in nitrogen deficient volunteer corn roots may be less than that of volunteer corn plants with sufficient nitrogen. Because all current Bt toxins are crystalline proteins, in-field factors such as soil nutrient levels (nitrogen, sulfur, etc.) could affect the expression levels of these proteins by corn plants. The western corn rootworm (WCR) is one of the primary pests of corn production, and is also the target pest of multiple Bt transgenes inserted into hybrid corn. WCR primarily feed on the roots of corn and physiologically damage the plant, reducing grain yield. The amount of adult WCR emergence from individual corn plants and root damage ratings have traditionally been used to determine the efficacy of WCR control strategies. Our objectives were to quantify the emergence of WCR adults and WCR corn root feeding damage in volunteer and hybrid corn growing in various nitrogen fertility environments. In the field, we planted three corn varieties (DKC 61-19 VT3 Cry3Bb1-positive hybrid corn, DKC 61-22 Cry3Bb1-negative hybrid corn, and an F_2 of DKC 61-19 VT3 Cry3Bb1-positive volunteer corn), and applied 5 rates of nitrogen (0, 45, 90, 180, and >200 kg N ha^{-1}). WCR emergence cages were placed over 120 individual corn plants in the two years of the study to collect adult beetles. We also assessed root damage due to WCR feeding by sampling corn roots and rating the roots on a 0-3 nodes of injury scale. Nitrogen rate did not effect WCR adult emergence or root damage. We also did not observe a difference in WCR adult emergence or root damage between volunteer corn expressing Bt and hybrid corn expressing Bt. While preliminary data have shown that nitrogen rate can effect Bt toxin expression, the effect of this variable toxin expression due to nitrogen was not observed in the WCR emergence or root damage data. It is possible that fields that are not supplied additional nitrogen fertility provide enough nitrogn for corn to produce sufficient Bt toxin. The WCR feeding pressure was also low in the two years of the study due to wet springs in 2010 and 2011 leading to high WCR mortality. Volunteer corn is a troublesome weed, but more field research is necessary to determine the effect of volunteer corn expressing Bt on insect resistance management plans.

WHEAT ROW SPACING AND SEEDING RATE EFFECT ON WEED EMERGENCE AND WHEAT YIELD. Douglas E. Shoup*; Kansas State University, Chanute, KS (85)

There is an increasing interest among producers to sow wheat with a 38-cm row planter vs. a traditional 18-cm row drill equipment. Wheat yield impacts and weed emergence patterns are unknown with this relatively new concept. The objectives of this study were to evaluate weed emergence, weed competition, and wheat yield effects when sowing wheat with a 38-cm row planter vs. 18-cm row drill equipment. Wheat was sowed October 21st, 2010 at the Ottawa experiment field. A high seeding rate of 3.7 million seeds ha^{-1} and low seeding rate of 2.5 million seeds ha^{-1} were sowed with the 18-cm row drill and the 38-cm row planter. Treatments were replicated four times in a pyroxsulam treated and untreated block. Henbit (*Lamium amplexicaule* L.), Carolina foxtail (*Alopecurus carolinianus* Walt.), and smallflowered bittercress (*Cardamine parviflora* L.) emergence was greater in the 38-cm wheat rows vs. the 18-cm wheat rows. The increase in emergence in the 38-cm wheat rows is likely because of less shading by the wheat. Seeding rate didn't affect weed emergence in the drilled wheat, however, significant differences in weed emergence did occur in the planted wheat. Henbit in the 38-cm wheat row at the low seeding rate emerged more than at the high wheat seeding rate at 152 vs. 109 plants m^{-2}, respectively. Smallflowered bittercress emergence was greater in the high seeding rate vs. low seeding rate in 38-cm row wheat at 70 vs. 45 plants m^{-2}, respectively. Wheat sowed with the 38-cm row planter in the pyroxsulam treated block yielded 5470 kg ha^{-1} less than wheat sowed with the 18-cm row drill. Wheat sowed with the 38-cm row planter in the untreated pyroxsulam block yielded 3832 kg ha^{-1} less than wheat sowed with the 18-cm row drill. Yield losses for the wheat in 38-cm rows in both herbicide treatment blocks are attributed to too wide of a row spacing to maximize yields.

WHERE HAS WEED SCIENCE BEEN AND WHERE IS IT GOING?; PERSPECTIVE OF A "MATURE" WEED SCIENTIST. Dale Shaner*; USDA, Fort Collins, CO (87)

Weed science is still a young field compared to other pest management disciplines. Prior to the discovery of the synthetic herbicides, weed management was not seen as a science. Weeds were a curse that had to be endured and could only be physically removed. Weed science took off with the discovery of the synthetic herbicides after World War II, although we have never reached the number of scientists in entomology or plant pathology. The emphasis on herbicides to manage weeds efficiently and economically has shaped our discipline. The use of herbicides has led to many discoveries in plant physiology, biochemistry as well as weeds ecology and weed competition. There have been many changes that have occurred in the last 15 years that will shape the future of weed science. The introduction of herbicide resistant crops (HRCs) revolutionized weed management but also led to some major problems in the selection of herbicide resistant weeds. One of the consequences of HRCs was a reduction in research efforts by industry to discover new herbicides. Now companies are trying to revitalize their efforts. Weed science will increase in value in the future with the need for greater food production on less land with fewer resources. The next generation of weed scientists will need to be trained not only in agronomy and basic weed management, but also in molecular biology, physiology, biochemistry, genetics, GIS/GPS, and analytical techniques. These disciplines are playing increasingly important roles in understanding weeds and developing new methods for management. There is a bright future for weed science as our discipline continues to grow and mature.

CAST REPORT. Duane Rathmann*; BASF Corp., Waseca, MN (89)

The NCWSS support of CAST (Council for Agricultural Science and Technology) and of our Science Policy Director in Washington represent two methods of outreach for a fair and accurate voice for agriculture. The mission of CAST is to "assemble, interpret, and communicate credible science based information regionally, nationally, and internationally to legislators, regulators, policymakers, the media, the private sector, and the public." Recognizing the need to adapt communication styles to different generations, the recent Borlaug CAST Communication Award was granted to Dr Carl Winter. The respected professor from the University of California--Davis is the author of two books and more than 100 publications. He serves on committees, teaches communication courses to graduate students, and testifies before the U.S. Congress on pesticide/food safety issues. But he is maybe best known for his version of America's Got Talent--Ag Style. Winter, the "Elvis of *E. coli*," has given nearly 200 live performances of his food safety music parodies at conferences, trade shows, and public gatherings during the past several years.

RESULTS FROM A TWO YEAR SURVEY OF STEM-BORING INSECTS FOUND IN MISSOURI WATERHEMP POPULATIONS. Brock S. Waggoner*, Kevin W. Bradley, Wayne C. Bailey; University of Missouri, Columbia, MO (93)

A field survey of stalk-boring insects (SBI) found in waterhemp (*Amaranthus rudis*) was conducted in Missouri soybean fields from July to September in 2011 and 2012. Across 169 separate field locations, twenty waterhemp plants were harvested; ten from within a 9-m area around the perimeter of each field (border) and ten from the inner area of each field. At each location, the tillage method, previous crop, and row spacing were also recorded to determine if these factors affected the presence, number, and diversity of SBI. Across 169 locations surveyed, 86% of the fields had feeding from SBI in at least one plant, with 38% of the total number of plants harvested exhibiting tunneling from SBI. SBI found in waterhemp, in order of reatest to least incidence, included larvae and adults of the tumbling flower beetle(*Mordellistena spp.*) and the clover stem borer (*Languria mozardi*), and larvae of snout beetles (*Lixus spp.*). All SBI found were from the order *Coleoptera*. A comparison of surveyed sites with SBI compared to those without indicated that tillage type, previous crop, or row spacing did not affect the presence, number, or diversity of SBI. In most instances, there were fewer than three tunnels found in dissected plants; 61% of waterhemp plants with tunneling had only one tunnel present, 24 % had two tunnels, 12% had 3 tunnels, and 3% had 4 tunnels or more. Generally, tumbling flower beetle and clover stem borer were found in waterhemp plants 100- to 150- cm in height while snout beetles were found in waterhemp 100-cm and smaller. Overall, the predominant effect that SBI had on waterhemp was in the form of an increase in plant height; waterhemp with SBI averaged 112-cm compared to 99-cm plants that did not have evidence of SBI or SBI feeding. Based on visual observations, all species were predominantly feeding in the pith tissue of waterhemp. Results from this survey indicate that: 1) the presence of SBI feeding in waterhemp is not affected by cultural practices, 2) SBI cause a physiological change in waterhemp plants in the form of increased plant height, and 3) SBI are widely distributed throughout the state of Missouri.

WHEN IS THE BEST TIME FOR EMERGENCE: FLOWERING PHENOLOGY, SEED PRODUCTION AND SEED CHARACTERISTICS OF NATURAL COMMON WATERHEMP (*AMARANTHUS TUBERCULATUS* (MOQ) SAUER) COHORTS. Chenxi Wu*[1], Micheal D. Owen[2]; [1]University of Illinois at Champaign-Urbana, Urbana, IL, [2]ISU, Ames, IA (94)

In 2009 and 2010, field and laboratory studies were conducted to evaluate temporal variation in flowering patterns and the reproductive biology of natural common waterhemp (*Amaranthus tuberculatus*) cohorts, as well as variations in seed mass, seed maturation time and the seed after-ripening patterns among cohorts. We found that later common waterhemp cohorts flower quicker and had a relatively shorter flowering period when compared with earlier cohorts. Corresponding to rain events, common waterhemp cohorts exhibited a pulsed flowering pattern with multiple flowering peaks: the 2009 flowering pattern exhibited up to 7 distinct flowering pulses within 40 d and the 2010 flowering pattern had 8 flowering pulses scattered over a 60 d period This pulsed flowering pattern suggests that common waterhemp development is plastic enough to adapt flowering to variable environmental conditions in order to optimize successful pollination. Common waterhemp seed production was high throughout the growing season and was influenced by plant emergence timing and population densities. Common waterhemp cohorts needed the same amount of time to generate viable seeds in 2009 while the earliest cohort took significantly longer (30 days) to generate viable seeds than later cohorts (21 to 25 days) in 2010. Later cohorts might produce heavier seeds but the differences in seed mass among cohorts were not consistent among years. Seed after-ripening patterns differed among years. In 2009, seeds from different cohorts had similar after-ripening patterns. Newly harvested seeds have strong primary dormancy (<10% germination) which was gradually released during dry storage and reached maximum germination (>80%) rate at 4 months after harvest (MAH). However, germination dropped to 40% at 6 and 8 MAH, indicating the induction of secondary seed dormancy. In 2010, strong primary dormancy at harvest could not be released by dry after-ripening and there was a difference in seed dormancy among common waterhemp cohorts. More ecological knowledge about common waterhemp would help us develop better ideas for controlling common waterhemp.

THE EFFECT OF NITROGEN RATE ON VOLUNTEER CORN BT PROTEIN EXPRESSION. Paul T. Marquardt*, Christian Krupke, William G. Johnson; Purdue University, West Lafayette, IN (95)

Volunteer corn expressing herbicide resistance is a problematic weed. This issue is partially due to the increasing prevalence of stacking both herbicide and insect-resistant (mainly Bt) traits into the same genetically-modified plant. Previous research indicates that the Bt toxin concentrations in nitrogen deficient volunteer corn roots may be less than that of volunteer corn plants with sufficient nitrogen. Because all current Bt toxins are crystalline proteins, we hypothesized that in-field factors such as soil nutrient levels (nitrogen, sulfur, etc.) could affect the expression levels of these proteins by corn plants. Our objectives were to quantify the concentration of Bt expressed in volunteer and hybrid corn root tissue in various nitrogen fertility environments. We conducted two sets of experiments (field and greenhouse) to accomplish these objectives. Cry3Bb1 toxin levels in roots were determined using quantitative ELISA. In the field, we planted three corn varieties (DKC 61-19 VT3 Cry3Bb1-positive hybrid corn, DKC 61-22 Cry3Bb1-negative hybrid corn, and an F_2 of DKC 61-19 VT3 Cry3Bb1-positive volunteer corn), and applied 5 rates of nitrogen (0, 45, 90, 180, and >200 kg N ha^{-1}). Expression of Cry3Bb1 protein in root tissues from the field experiment was highly variable, but there was no difference in the overall concentration of Cry3Bb1 expressed in the root tissue between Cry3Bb1-positive volunteer corn (18.7 ± 2.70 ppm) and Cry3Bb1-positive hybrid corn (13.2 ± 2.93 ppm) at the V6 to V9 growth stage. Nitrogen rate did affect Cry3Bb1 expression in the field; lower rates of nitrogen resulted in decreased Cry3Bb1 expression. We also conducted a greenhouse trial to quantify Cry3Bb1 expression in hybrid and volunteer corn growing in 5 nitrogen fertility environments (0, 25, 50, 100, and 200 mg N L^{-1}). DKC 61-19 was used as the Cry3Bb1-positive hybrid corn and the F_2 of DKC 61-19 was used as the Cry3Bb1-positive volunteer corn. All plants were harvested at the V6 growth stage. Root and shoot biomass was quantified after drying, and root tissue samples were collected at harvest to quantify Bt expression. As with the field experiment, there was no difference in Cry protein expression between volunteer corn (6.94 ± 1.24 ppm) and hybrid corn (9.32 ± 1.23 ppm). As in the field experiment, there was an effect of nitrogen on Cry3Bb1 expression. When nitrogen was not applied there was less Cry3Bb1 expressed in volunteer corn plants. Interestingly, this effect was not observed in hybrid corn. These data illustrate that reduced volunteer corn Cry toxin expression may be more typically observed in soybean fields where nitrogen is not applied, and volunteer corn plants would be nitrogen deficient. In addition to being a troublesome weed, volunteer corn may be problematic for insect resistance management plans by exposing the target insects to sublethal doses of the toxin. Recent data has illustrated that the acetyl-CoA carboxylase inhibitor, clethodim, (a commonly used herbicide for POST volunteer corn control in soybean) also has reduced efficacy on nitrogen deficient volunteer corn. Thus, in order to control Cry3Bb1-positive volunteer corn, and decrease the likelihood of insects feeding on sublethal doses of the toxin, it is advisable to control volunteer corn in soybean early in the season and follow recommended herbicide use rates.

ENVIRONMENTAL TRIGGERS OF WINTER ANNUAL WEED EMERGENCE. Rodrigo Werle*[1], Andrew J. Tyre[1], Mark L. Bernards[2], Timothy J. Arkebauer[1], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL (96)

Winter annual weeds are becoming more common in many row crop fields in the Midwestern USA. These species typically emerge in the fall and complete their life cycle near the time of crop sowing in the spring. The objectives of this research were to understand the roles of soil temperature (daily average and fluctuation) and moisture on the emergence process of nine winter annual weed species and dandelion, and also to develop predictive models for weed emergence based on the accumulation of modified thermal/hydrothermal time (*m*HTT). Research plots 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 15x20x5 cm mesh cages installed between soybean rows. Soil temperature and moisture were recorded at 2 cm depth in the soil. Emerged seedlings were counted and removed from the cages on a weekly basis until no additional emergence was observed in the fall, then counts were resumed in late winter after plants began emerging again and continued until emergence ceased in late spring. Emergence data were converted from weekly counts to cumulative emergence (%). Weather data was used to accumulate *m*HTT beginning on August 1. A Weibull function was selected to fit cumulative emergence (%) on cumulative *m*HTT (7 base temperature [T_{base}] x 6 base water potential [Ψ_{base}] x 3 base temperature fluctuation [F_{base}] candidate threshold values = 126 models) and also to days after August 1 (DAA1), for a total of 127 candidate models. The search for optimal base thresholds (T_{base}, Ψ_{base}, and F_{base}) was based on the theoretic-model selection approach (AIC criterion), which indicated the importance of, and the optimum base value for each component. A simple model including only T_{base} provided the best fit to the data for most species included in this study (Carolina foxtail, shepherd's purse, tansymustard, henbit, and field pansy). For field pennycress, a model based only on DAA1 resulted in the best fit. The best fit was achieved for downy brome and purslane speedwell by including T_{base}

and Ψ_{base}, and for dandelion by including T_{base} and F_{base}. Including all three components improved model fit only for Virginia pepperweed. As expected, optimal base threshold values were species-specific. Soil temperature was the most important factor related to winter annual weed emergence. Soil moisture and temperature fluctuation were not as critical as initially hypothesized in influencing time of emergence. Our predictive models can help growers to make better management decisions regarding winter annual weeds.

POLLEN VIABILITY OF *AMARANTHUS* SPECIES IN VITRO. Tye C. Shauck*, Reid J. Smeda; University of Missouri, Columbia, MO (97)

Pollen is an effective mechanism for spreading herbicide resistance across a broad geography. *In vitro* systems can be used to assay pollen for expression of herbicide resistance or determine viability following release from anthers. However, *in vitro* germination only occurs when the optimal stigma interaction and environmental conditions are simulated. The objective of this study was to determine the optimal pH and incubation temperature for germination of common waterhemp (*Amaranthus rudis*) and Palmer amaranth (*Amaranthus palmeri*) pollen *in vitro*. The germination media was adopted from Bodhipadma et al. 2010, and contained 20% (w/v) sucrose, 1 mM calcium chloride, 0.1 mM boric acid, and 0.8% (w/v) agar. Initial pollen viability was assessed with Alexander's stain; 100 pollen grains were determined viable or non-viable. Media pH was established at 1 unit increments from 4.5 to 8.5, heated, and placed on different microscope slides to solidify. Pollen from one plant, considered one replication, was then distributed onto the microscope slides. Directly after pollen deposition, microscope slides were incubated in a water bath for three hours at 20, 25, 28, 32, 38, or 43 C. Pollen on the germination media was stained with aniline blue to enhance the identification of elongated pollen tubes (factor considered to indicate germination). Using a grid, one hundred pollen grains were randomly scored as germinated or non-germinated. Percent germination of pollen was then adjusted by the percentage of viability for each plant as determined with Alexander's stain. Alexander's stain indicated that common waterhemp and Palmer amaranth pollen viability ranged from 79 to 100% (mean = 92%) and 83 to 100% (mean = 94%), respectively. Following treatment, pollen germination ranged from 0 to 73% for common waterhemp and 0 to 18% for Palmer amaranth. Media pH and incubation temperature, as well as their interaction, were significant factors effecting pollen tube germination. Optimum germination for pollen of both species occurred between 32 and 38 C and a pH of 4.5 to 5.5. An incubation temperature of 32 C and pH of 5.5 resulted in the highest germination, 20.4 and 8.8% for common waterhemp and Palmer amaranth, respectively. For both species, a temperature below 28 C or above 42 C resulted in pollen germination ranging from 0 to 7.4%; at a pH of 6.5 or higher pollen germination was 0 to 0.5%. Germination of *Amaranthus* pollen *in vitro* is possible through media manipulation of pH and temperature; further investigations of media components are needed to increase germination.

WATERHEMP RESISTANCE TO POST-EMERGENT APPLICATION OF HPPD HERBICIDES. Neha Rana*[1], Jon E. Scott[1], Aaron S. Franssen[2], Vinod K. Shivrain[3], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE, [3]Syngenta Crop Protection, Vero Beach, FL (98)

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 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 (15 and 30 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 15 and 30 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 ED_{70} values were determined for 30 cm tall waterhemp because the herbicide rates were not high enough to provide 80% control. 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.

PRESENCE AND CHARACTERIZATION OF GLYPHOSATE RESISTANT COMMON WATERHEMP AND PALMER AMARANTH IN KANSAS. Josh A. Putman*; Kansas State Univeresity, Manhattan, KS (99)

Common waterhemp and Palmer amaranth are troublesome pigweed species that can reduce crop yields significantly. They are both dioecious species and can produce more than one million seeds per plant. Common waterhemp was first confirmed to be resistant to glyphosate in northeast Kansas in 2006. Glyphosate-resistant Palmer amaranth is a major problem in the southeastern United States, but has not been previously confirmed in Kansas. The objective of this research was to document the presence and scope of glyphosate-resistant common waterhemp and Palmer amaranth in eastern Kansas. Seed from 15 populations of common waterhemp and 8 populations of Palmer amaranth were collected from soybean and cotton fields throughout eastern Kansas in the fall of 2011. Seed was threshed and placed in storage at -5ºC until planted. Seed was sown into separate flats and allowed to germinate. Susceptible check populations of each species were grown simultaneously. Individual seedlings were transplanted into 0.25 L pots when plants were at the cotyledon stage of growth and watered as needed. Plants measuring 10 to 14 cm in height were treated with glyphosate at rates of 0, 840, 1,680, and 3,360 g ae ha^{-1}, respectively. The experiment had a randomized complete block design with 8 replications and was repeated. Percent injury and mortality was determined 7 and 14 days after treatment (DAT) where 0 = no effect and 100 = complete plant death. Glyphosate effectively controlled the susceptible check populations resulting in complete plant mortality. However, multiple populations of common waterhemp survived applications of glyphosate up to 4 times the suggested use rate. Visual injury varied 10 to 100% depending on the population, and rate. Two populations of Palmer amaranth showed similar resistance characteristics, with some plants surviving 4 times the suggested use rate of glyphosate. Glyphosate-resistant common waterhemp is present across much of eastern Kansas and appears to be spreading. Glyphosate-resistant Palmer amaranth is now present in south central Kansas and will likely become more widespread in the future.

SENSITIVITY OF GLYPHOSATE-RESISTANT *AMARANTHUS* TO GLYPHOSATE IS ALTERED BY SOIL APPLIED NITROGEN. Jon R. Kohrt*, Bryan G. Young, Joesph L. Matthews, Julie M. Young; Southern Illinois University, Carbondale, IL (100)

The phenotypic expression of glyphosate resistance in *Amaranthus* populations may be influenced by herbicide application variables such as field and environmental conditions. Previous field observations of improved control of glyphosate-resistant (GR) common waterhemp populations with glyphosate in corn production compared with soybean suggest that the presence of nitrogen fertilizer may influence the phenotypic expression of glyphosate resistance. Field and greenhouse experiments were conducted to determine the influence of soil-applied nitrogen fertilizer on the growth rate and sensitivity of glyphosate-resistant Palmer amaranth and common waterhemp to glyphosate. Field experiments with GR waterhemp were conducted in De Soto, IL in 2011 and 2012 while experiments with GR Palmer amaranth were conducted in Collinsville and Valmeyer, IL in 2012. In the greenhouse the addition of supplemental nitrogen fertilizer increased the relative growth rate, as a function of shoot height and volume, of glyphosate-susceptible and –resistant common waterhemp and Palmer amaranth. The glyphosate-susceptible populations of both common waterhemp and Palmer amaranth were more sensitive to glyphosate under high nitrogen rate compared to no nitrogen. However, only the GR common waterhemp was sensitive to glyphosate applications under high nitrogen and the same was not observed for Palmer amaranth. Ultimately, the higher application rate of nitrogen reduced the magnitude of resistance in common waterhemp, but not Palmer amaranth as that species exhibited exceptionally high magnitudes of resistance in the greenhouse which likely masked any influence of nitrogen. Field experiments confirmed the possibility that nitrogen fertilizer can influence the response of glyphosate-resistant amaranth to glyphosate, but the results were variable, which suggests the importance of soil moisture and other environmental variables in the field. In summary, the application of nitrogen fertilizer, or lack thereof, may influence the survival of common waterhemp and Palmer amaranth plants in fields infested with glyphosate-resistant populations.

INTERACTIONS BETWEEN GLYPHOSATE, *FUSARIUM* INFECTION OF WATERHEMP, AND SOIL MICROORGANISMS. Kristin K. Rosenbaum*, Lee Miller, Robert Kremer, Kevin W. Bradley; University of Missouri, Columbia, MO (101)

Greenhouse and laboratory experiments were conducted on waterhemp (*Amaranthus rudis* Sauer) and soil collected from 144 soybean fields in Missouri that contained late-season waterhemp escapes. The objectives of these experiments were to: 1) determine the frequency and distribution of glyphosate resistance in Missouri, 2) determine the effects of soil sterilization on glyphosate-resistant (R) and susceptible (S) waterhemp survival, 3) determine the effects of soil sterilization and glyphosate treatment on infection of R and S waterhemp biotypes by Fusarium spp., and 4) determine the soil microbial abundance and diversity (phospholipid fatty acid analysis (PLFA)) in soils collected from soybean fields with differences in R and S waterhemp biotypes, variable herbicide and glyphosate use histories, and differences in crop rotation. Glyphosate-resistance was confirmed in 99 out of 144, or 69% of the total waterhemp populations surveyed. Crop and herbicide use history was obtained from each of the fields surveyed. Waterhemp biotypes were treated with 1.7 kg glyphosate ae/ha once plants reached approximately 15 cm in height or left untreated. Waterhemp survival was visually assessed at 1, 2, and 3 weeks after treatment (WAT). To determine *Fusarium* infection frequency, a single intact waterhemp root was harvested from each treatment at 1, 2, and 3 WAT, surface-sterilized with 10% NaClO solution, and 10-15 mm waterhemp root sections were plated on Komada culture medium. After 14 days incubation, fungal colonies were selected from colonized roots and maintained on potato dextrose agar medium amended with antibiotics chloramphenicol, streptomycin, and tetracycline before identification. *Fusarium* isolates were examined microscopically and tentatively identified to species. Identification was confirmed via genomic DNA extraction, and subsequent PCR amplification and sequence analysis of the internal transcribed spacer (ITS) region. Waterhemp plants grown in sterile soils had the highest waterhemp survival, regardless of biotype. Survival of S waterhemp grown in non-sterile soil and treated with glyphosate was only 10% 3WAT, while survival of S waterhemp grown in sterile soil was 29%. Similarly, R waterhemp survival was reduced from 83 to 61% when grown in sterile compared to non-sterile soil. The greatest occurrence of *Fusarium* root infection in waterhemp occurred in non-sterile soil with a glyphosate treatment. *Fusarium* spp. were recovered from only 14% of the assayed roots (271 treatments with *Fusarium* out of a total 1920 treatments). The most predominant species recovered were *Fusarium solani* (the group that includes the causal agent of sudden death syndrome) and *Fusarium oxysporum* (may be causal agent of vascular wilt). As determined by PLFA, no differences in total PLFA, bacteria, fungi, protozoa, saturated PLFA, monosaturated PLFA, and PLFA biomarkers for arbuscular mycorrhizal fungi, gram positive and gram negative bacteria were observed in field soil collected from locations with either glyphosate R or S waterhemp, and regardless of crop rotation or herbicide-use history. This research supports previous findings with other crop and weed species that indicate plants are more sensitive to glyphosate in non-sterile than sterile soils and that glyphosate may predispose plants to soilborne phytopathogens. The results from this research also suggest that continuous use of glyphosate does not significantly affect soil microbial abundance or diversity.

EMERGENCE AND CONTROL OF PUTATIVE HERBICIDE-RESISTANT WATERHEMP. Lacy J. Valentine*[1], Greg R. Kruger[2], Lowel Sandell[3], Zac J. Reicher[1], Patrick Tranel[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Illinois, Urbana, IL (102)

Field studies were conducted to evaluate control of a putative herbicide-resistant common waterhemp population in southeast Nebraska. Results from previous studies indicated that the population was resistant to acetolactate synthase (ALS)-inhibiting herbicides. Field studies examined differential response of the population to ALS-inhibiting, protoporphyrinogen oxidase (PPO)-inhibiting, and seedling growth inhibiting herbicides. Unacceptable control was achieved with seedling growth inhibiting herbicides applied as preemergent control. No treatment achieved greater than 50% visual control or significant reduction of above-ground dry biomass (less than 63 g). Split applications did reduce variance by 66%. Satisfactory control (greater than 75% visual control) was achieved with postemergent applications when ALS-inhibiting, seedling growth inhibiting, and PPO-inhibiting herbicides were applied as a tank-mix combination. The results from these experiments provide evidence of alternate control methods such as split applications and tank-mix combinations that improve control of herbicide-resistant common waterhemp

WEED HOSTS OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS*, CAUSAL AGENT OF GOSS'S BACTERIAL WILT AND LEAF BLIGHT. Joseph T. Ikley*, William G. Johnson, Kiersten A. Wise; Purdue University, West Lafayette, IN (103)

Goss's Bacterial Wilt and Leaf Blight of corn is caused by the bacterium *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). Since 2006, this disease has become widespread throughout the Midwest. Cmn has been documented to cause up to a 44% yield loss in corn. Currently, there are no effective chemical treatments for control of this disease. Tillage and rotating to a non-host crop are currently the best management options. Some weed species have been documented to be a host of Cmn, therefore controlling weed hosts can reduce inoculum levels in a field. Currently known weed hosts of Cmn include shattercane (*Sorghum bicolor*) and four common foxtail (*Setaria*) species. Giant foxtail (*Setaria faberi*) is a late season escape in 10% of soybean fields in Indiana, and the presence of giant foxtail in these fields could potentially negate the benefits of crop rotation for Cmn management. The objective of this study was to determine if 15 common weed species and two commonly used cover crops are hosts of Cmn. Plants were inoculated with a suspension of 1.0×10^8 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 examined for bacterial streaming, and leaf tissue was plated onto Cmn-selective medium. Controlling weed hosts of Cmn is a factor in the management of this disease that is often overlooked. This study reveals the importance of weed control in disease management.

INTEGRATED WEED MANAGEMENT USING ROW SPACING, COVER CROPS, AND SOYBEAN VARIETIES. Amanda M. Flipp*[1], Gregg Johnson[2], Jeffrey Gunsolus[3], Donald Wyse[2]; [1]University of Minnesota - Twin Cities, St. Paul, MN, [2]Univeristy of Minnesota, St. Paul, MN, [3]University of Minnesota, St. Paul, MN (104)

Glyphosate resistant weeds are becoming more prevalent in fields throughout Minnesota. Furthermore, some of the weed populations resistant to glyphosate are also resistant to other herbicide mechanisms of action thereby limiting the availability of herbicide-based weed control strategies. This study was designed to evaluate an integrated approach to weed management that utilizes multiple tactics to reduce seed rain and the weed seedbank. Field studies were conducted to evaluate several combinations of weed suppression tactics which included soybean row spacing, cover crops, and soybean varieties on *Chenopodium album* (common lambsquarters), *Amarantus tuberculatus* (tall waterhemp), and *Ambrosia trifida* (giant ragweed) emergence, growth, and seed production. The study was designed as a split-split plot arrangement and conducted at two sites at the University of Minnesota Southern Research and Outreach Center in 2011 and 2012. A winter rye cover and preemergence herbicide (flumioxain) reduced weed emergence equally well while the radish/pennycress cover was similar to the control. However, in both years the plots with winter rye reduced soybean canopy closure, which exposed the soil to more light for a longer period of time. This could be a potential problem for late emerging weeds, as they could germinate, and still produce viable seeds, adding to the weed seed bank. Row spacing influenced light interception later in the summer, with the narrow rows closing 10 to 14 days earlier than the wide rows. Soybean varieties interacted with other factors to result in enhanced weed management. For example, in 2011 weed emergence was impacted by a combination of soybean variety and row spacing to reduce the total weeds that emerged between soybean emergence and V3-V4 stage of soybean growth. Each factor independently was not significant, but together they showed an effect on weed development. Giant ragweed was the most challenging weed species to control in this study due to early emergence and the competitive nature of this species. Preliminary results suggest that early season weed suppression, either through integration of winter rye or a preemergence herbicide, could be an important component of herbicide resistance management. However, more research is needed to determine the effect of an integrated weed management strategy on weed seed rain and seed bank management.

ALLELOPATHY OF SUDANGRASS COVER CROP ON GREEN FOXTAIL. Jared J. Schmidt*[1], Sam E. Wortman[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Illinois Urbana-Champaign, Urbana, IL (105)

Chemical allelopathy of sorghum species has been shown to inhibit germination and growth of other species. Both the chemical sorgoleone produced by sorghum roots, and phenolic acids produced in the decomposition of sorghum tissue have been shown to reduce growth or germination of other species. Experiments were conducted at the University of Nebraska-Lincoln to quantify suppression of germination and growth of green foxtail when planted in soil previously conditioned by growing sudangrass and also by incorporating sudangrass shoot tissue into the soil. Three soil types were used, a high organic matter potting mix, a low organic matter 1:1:1 mixture of soil: sand:vermiculite and a medium organic matter 3:1:1 mixture of soil:sand: vermiculite. Half the pots were conditioned by growing sudangrass for approximately 5 weeks. The sudangrass plants were removed from the soil and the shoots were cut into approximately 1.5 cm segments. Green foxtail was planted into one of four treatments: Unconditioned soil, with and without sudangrass shoot residue incorporated into the upper 2 cm of soil; and sudangrass conditioned soil, with and without shoot residue. The experiment was conducted twice. Both sudangrass conditioned soil and sudangrass mulch reduced total emergence in the low and medium organic matter treatments with the most reduction occurring in the conditioned soil + mulch treatment. In the high organic matter treatment the conditioned soil and conditioned soil + mulch reduced total emergence but the mulch alone did not. This might suggest that phenolic acids might be affected or adsorbed by organic matter. In run 1 emergence timing was also affected where conditioned soil and conditioned soil + mulch tended to delay time to 50% cumulative emergence, with the greatest delay occurring in the conditioned soil + mulch treatment. There was no effect of soil type in run 1. In the second run of the experiment emergence was delayed in the low and medium organic matter treatment in the conditioned soil + mulch treatments.

PROGRAMS FOR THE MANAGEMENT OF GLYPHOSATE-RESISTANT WATERHEMP AND GIANT RAGWEED IN DICAMBA-RESISTANT SOYBEAN. Doug J. Spaunhorst*[1], Simone Seifert-Higgins[2], Christopher M. Mayo[3], Eric B. Riley[4], Kevin W. Bradley[4]; [1]University of Missouri-Columbia, Columbia, MO, [2]Monsanto Company, St. Louis, MO, [3]Monsanto Company, Gardner, KS, [4]University of Missouri, Columbia, MO (106)

Field experiments were conducted across two locations during 2011 and 2012 to evaluate herbicide options for the control of glyphosate-resistant (GR) giant ragweed (Ambrosia trifida L.) and GR waterhemp (Amaranthus rudis Sauer) in dicamba-tolerant (DT) soybean. In the GR giant ragweed experiment, all pre-plant treatments included 0.86 kg ha^{-1} glyphosate alone or combined with: 0.071 kg ha^{-1} flumioxazin plus 0.56 kg ha^{-1} 2,4-D; 0.071 kg ha^{-1} flumioxazin plus 0.56 kg ha^{-1} dicamba; 0.071 kg ha^{-1} flumioxazin plus 0.022 kg ha^{-1} chlorimuron plus 0.56 kg ha^{-1} dicamba; or 0.155 kg ha^{-1} sulfentrazone plus 0.02 kg ha^{-1} chlorimuron plus 0.56 kg ha^{-1} dicamba. Regrowth applications occurred when GR giant ragweed measured 10- or 20-cm in height. All regrowth applications contained 0.86 kg ha^{-1} glyphosate applied alone or in combination with one of the following: 0.56 kg ha^{-1} dicamba, 0.34 or 0.39 kg ha^{-1} fomesafen, or 0.018 kg ha^{-1} cloransulam. In the GR waterhemp experiment, initial herbicide applications were applied pre-emergence (PRE) or post-emergence (POST) when plants measured 10- or 20-cm in height. A regrowth application followed when GR waterhemp measured 10-cm in height. The PRE treatments evaluated included 0.071 kg ha^{-1} flumioxazin plus 0.022 kg ha^{-1} chlorimuron. All POST and/or regrowth applications included: 0.86 kg ha^{-1} glyphosate applied alone or in combination with 0.34 kg ha^{-1} fomesafen; 0.39 kg ha^{-1} fomesafen; 0.56 kg ha^{-1} dicamba; or 0.56 kg ha^{-1} dicamba plus 1.27 kg ha^{-1} acetochlor. A non-treated control was included in both experiments for comparison. Visual control of GR giant ragweed and waterhemp was determined 21 days after application (DAA) of the regrowth applications. All treatments provided 91- to 100% control of GR giant ragweed 21 DAA, regardless of pre-plant application treatment or GR giant ragweed height at the time of the regrowth application. Control of GR waterhemp with glyphosate alone was less than 24%. When dicamba was included in both POST applications, GR waterhemp control ranged from 88- to 94%. PRE herbicide treatments followed by dicamba plus glyphosate provided 39% higher control of GR waterhemp compared to the same PRE treatment followed by glyphosate alone. An initial application of glyphosate plus fomesafen to 10-cm GR waterhemp followed by glyphosate to 10-cm regrowth provided only 44% control of GR waterhemp. When the initial application timing was delayed to 20-cm with this same treatment, GR waterhemp control 21 DAA was less than 24%. Results from these experiments suggest that pre-plant herbicide treatments that include dicamba, 2,4-D, flumioxazin, flumioxazin plus chlorimuron, or sulfentrazone plus chlorimuron will provide 91% or greater control of GR giant ragweed. Additionally, timely sequential POST applications of dicamba plus glyphosate provided at least 88% GR waterhemp control, which was comparable to the level of GR waterhemp control achieved with PRE followed by POST herbicide programs that contained dicamba. The highest level of GR waterhemp control was achieved with sequential post applications of dicamba plus glyphosate plus acetochlor, which suggests that the use of overlapping residuals will be a key component in eliminating additional flushes of GR waterhemp.

IMPACT OF PLANT HEIGHT ON *AMARANTHUS SPP*. RESPONSE TO DICAMBA. Ashley A. Schlichenmayer*[1], Reid J. Smeda[2]; [1]University of Missouri, Columbia, Columbia, MO, [2]University of Missouri, Columbia, MO (107)

The increasing incidence of glyphosate-resistant common waterhemp (*Amaranthus rudis*) and Palmer amaranth (*Amaranthus palmeri*) in Missouri soybean fields indicates alternative approaches for management are needed. Coming technologies such as dicamba-resistant soybean offers a new approach, but the rate and plant size of *Amaranthus* species for effective control is not clear. Field studies near Columbia and Portageville, MO were established in sites infested with glyphosate-resistant waterhemp and Palmer amaranth, respectively. A glufosinate-tolerant soybean was planted in early May into conventionally tilled areas. Emerging *Amaranthus* plants were covered with plastic cups and glufosinate applied broadcast at 0.45 kg ai/ha to result in four target plant sizes: 5 to 10 cm; 12 to 18 cm, 20 to 25 cm and 28 to 36 cm. Up to six plants in each plot were then treated with 0.28, 0.42, 0.56, 0.84 or 1.12 kg ae/ha dicamba, and 0.84 or 1.12 kg ae/ha 2,4-D; an untreated control was also included. Studies were set up as a two factor factorial in a randomized complete block design with five replications. Data collected included visual ratings (0 = no control and 100 = plant death) at 28 days after treatment as well as plant biomass. Because the soybean variety used was not tolerant to dicamba or 2,4-D, plants died following treatment. For both waterhemp and Palmer amaranth, there was an expected increase in control with increasing rates of dicamba, and a step-wise reduction in control as the treated plant size increased. Averaged across plant size, waterhemp control was optimal at 0.84 kg/ha (91%), with the same rate resulting in 79% control of Palmer amaranth. Statistically, control of both species with 2,4-D at 1.12 kg/ha was equivalent to 0.84 kg/ha of dicamba. Comparison of each plant size across dicamba rates indicates that optimal control of waterhemp resulted from 0.84, 0.56, 0.56, and 0.84 kg/ha at 5 to 10, 12 to 18, 20 to 25, and 28 to 36 cm plants, respectively. For Palmer amaranth, optimal control resulted from 0.42, 0.56, 0.42, and 0.56 kg/ha at the four respective plant sizes. Under very dry field conditions, results suggest that Palmer amaranth was more difficult to control with dicamba than waterhemp; increasing the dicamba rate had a greater impact on improving waterhemp control than Palmer amaranth. Adequate control of *Amaranthus* species with dicamba will require the proper rate on smaller (less than 18 cm) plants.

SOYBEAN TOLERANCE TO SINGLE AND MULTIPLE FLAMING. Stevan Z. Knezevic*[1], Avishek Datta[2], Strahinja V. Stepanovic[3], Dejan Nedeljkovic[4], Nihat Tursun[5], Neha Rana[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska - Lincoln, Lincoln, NE, [4]University of Belgrade, Belgrade, Serbia, [5]Kahramanmaras Sutcu Imam University, Kahramanmaras, Turkmenistan (108)

Field experiments were conducted to study the impact of single and multiple flaming on crop injury, yield components, and yield of soybean. The goal of this experiment was to determine the number of the maximum flaming treatments which soybean could tolerate without any yield loss. The treatments consisted of a non-flamed control, and broadcast flaming conducted one time (at VC-unfolded cotyledon, V2-second trifoliate, and V5-fifth trifoliate), two times (each at VC and V2, VC and V5, and V2 and V5 stages), and three times (at VC, V2, and V5 stages) resulting in a total of eight treatments. All plots were kept weed-free for the entire growing season by hand hoeing. A propane dose of 45 kg ha^{-1} was applied with torches parallel to the crop row and at an operating speed of 4.8 km h^{-1} for all treatments. The response of soybean was measured as visual injury ratings (at 7 and 28 days after treatment-DAT) as well as effects on yield components and yield. Broadcast flaming conducted once (at VC or V5 stage), as well as twice (at VC and V5 stages) exhibited the lowest injury of about 8% at 28 DAT. Any treatment that contained flaming at V2 stage resulted in more than 70% injury at 28 DAT. The highest crop yields were obtained from the non-flamed control (3.45 t ha^{-1}) and the plots flamed once at VC (3.35 t ha^{-1}), V5 (3.32 t ha^{-1}), and two times at VC and V5 (3.24 t ha^{-1}), which were all statistically similar. Soybean flamed at V2 stage had lower yields (1.03 t ha^{-1} at V2, 0.46 t ha^{-1} at VC and V2, and 0.38 t ha^{-1} at V2 and V5). The lowest yields were in soybean flamed three times (VC, V2, and V5 stages), which yielded only 0.36 t ha^{-1}. These results indicated that soybean could tolerate a maximum of two flaming treatments at VC and V5 growth stages per season without any yield reduction (sknezevic2@unl.edu).

INVESTIGATIONS OF WEED MANAGEMENT PROGRAMS FOR USE IN SOYBEANS WITH RESISTANCE TO HPPD-INHIBITING HERBICIDES. John Schultz*[1], Michael L. Weber[2], Jayla Allen[3], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]Bayer CropScience, Indianola, IA, [3]Bayer CropScience, Research Triangle Park, NC (109)

Separate field trials were conducted in 2012 near Moberly and Columbia, Missouri to evaluate weed management programs in FG72 soybeans resistant to HPPD-inhibiting herbicides. Treatments consisted of pre-emergence followed by post-emergence (PRE fb POST), two-pass POST, and one-pass POST herbicide programs that contained various rates and application timings of isoxaflutole, *S*-metolachlor, metribuzin, glyphosate, mesotrione, pyroxasulfone and fomesafen. POST applications were made once weeds reached approximately 10-cm in height. Visual crop injury and weed control ratings were determined at 7, 14, and 28 days after application (DAA) along with weed density and biomass from a 1-m^2 area within each plot 28 DAA. All treatments were arranged in a randomized complete block design with six replications. A non-treated control was included for comparison. At the Columbia research site, similar levels of giant foxtail (*Setaria faberi*), ivyleaf morningglory (*Ipomoea hederacea*), common cocklebur (*Xanthium stumarium*), large crabgrass (*Digitaria sanguinalis*), prickly sida (*Sida spinosa*), common sunflower (*Helianthus annuus*) and glyphosate-susceptible common waterhemp (*Amaranthus rudis*) control were achieved with most of the PRE fb POST herbicide programs. Visual control of giant foxtail, common cocklebur, large crabgrass, prickly sida, and glyphosate-susceptible waterhemp was reduced by as much as 29% with one-pass POST herbicide programs containing isoxaflutole compared to PRE fb POST herbicide programs. In most instances, late-season measurements of weed biomass response to the herbicide programs correlated with visual weed control evaluations. A PRE fb POST program of *S*-metolachlor plus metribuzin followed by glyphosate resulted in a 76% reduction in weed biomass compared to the non-treated control. PRE fb POST applications of mesotrione and *S*-metolachlor followed by glyphosate also resulted in a 99% reduction in weed biomass compared to the non-treated control. At the Moberly research site, PRE fb POST herbicide programs resulted in at least 79% control of glyphosate-resistant (GR) waterhemp 28 DAA while POST applications of glyphosate alone or glyphosate plus isoxaflutole, fomesafen, or *S*-metolachlor provided only 21% to 38% control of GR waterhemp. Reductions in GR waterhemp biomass also indicated that the two-pass POST program containing glyphosate alone provided only 45% biomass reduction while one-pass POST programs provided 49% to 70% weed biomass reduction, and two-pass POST and PRE fb POST programs reduced weed biomass by 83% to 100% . Overall, results from these experiments indicate that PRE fb POST programs generally provide higher levels of weed control when compared to two-pass POST programs and one-pass POST programs that contain isoxaflutole. Additionally, the incorporation of a novel mode of action in soybean to control both resistant and susceptible biotypes will provide a more diverse chemical portfolio for producers to utilize.

CONTROL AND DISTRIBUTION OF GLYPHOSATE RESISTANT GIANT RAGWEED IN ONTARIO. Joanna Follings*[1], Peter Sikkema[2], François Tardif[1], Darren E. Robinson[3], Mark Lawton[4]; [1]University of Guelph, Guelph, ON, [2]University of Guelph - Ridgetown Campus, Ridgetown, ON, [3]University of Guelph, Ridgetown, ON, [4]Monsanto Canada, Guelph, ON (110)

Giant ragweed (*Ambrosia trifidia*) was the first glyphosate resistant weed in Canada. Giant ragweed interference in soybean has resulted in yield losses of greater than 90%; therefore, control of this competitive weed is essential. The objectives of this research were: a) to conduct an expanded field survey to document the distribution of glyphosate resistant giant ragweed in Ontario, b) to determine effective control options for glyphosate resistant giant ragweed in soybean, and c) to ascertain the biologically effective rate of 2,4-D for the control of glyphosate resistant giant ragweed. In 2011, giant ragweed seed was collected from 51 sites in Essex (16), Kent (20), Lambton (10), Middlesex (2), Elgin (2) and Lennox & Addington (1) counties. Glyphosate was applied to giant ragweed seedlings at 1800 g ae/ha and resistant or susceptible ratings were taken at 1, 7, 14 and 28 days after application. Results from the 2011 survey concluded that there were 23 additional sites with glyphosate resistant giant ragweed in Ontario. An additional survey will be conducted in the fall of 2012. Field trials were conducted at 5 sites in 2011 and 2012 to determine the most effective control options. Based on these experiments, glyphosate tankmixes with 2,4-D or amitrole provide the most effective control. These two tankmixes provided greater than 90% control. The minimum dose of 2,4-D required for acceptable control of glyphosate resistant giant ragweed is 500 g/ha.

COMPARISON OF HERBICIDE PROGRAMS IN GLYPHOSATE- AND GLUFOSINATE-RESISTANT SOYBEAN.

Jeff M. Stachler*; NDSU and U. of MN, Fargo, ND (111)

Limited data is available comparing weed control systems in glyphosate-resistant soybean to glufosinate-resistant soybean in a glyphosate-resistant weed population. A small-plot research trial was established to address the following objectives: 1. Determine effectiveness of various herbicide programs in glyphosate- and glufosinate-resistant soybean; 2. Determine effectiveness of various preemergence herbicides in glyphosate- and glufosinate-resistant soybean; and 3. Determine yield differences between herbicide programs in glyphosate- and glufosinate-resistant soybean. The trial was established in a glyphosate-resistant waterhemp population near Holloway, MN and a glyphosate-resistant common ragweed population near Buxton, ND. The herbicide programs included glyphosate (1.68 kg ae/ha followed by 0.84 kg/ha) alone and glufosinate (0.59 kg ai/ha followed by 0.59 kg/ha) alone, glyphosate and glufosinate plus an additional postemergence herbicide, preemergence followed by glyphosate and glufosinate alone, glyphosate and glufosinate applied early postemergence plus an acetamide herbicide and plus an additional postemergence herbicide, preemergence followed by glyphosate and glufosinate plus an additional postemergence herbicide, and preemergence followed by glyphosate and glufosinate plus an acetamide herbicide plus an additional postemergence herbicide. Glyphosate and glufosinate were applied at the same rates when in mixtures as applied alone. All herbicide treatments were applied with a bicycle sprayer calibrated to deliver 159 l/ha at 276 kPa. Glyphosate- and glufosinate-resistant soybean were planted on April 25 and May 3, 2012 at Holloway, MN and Buxton, ND, respectively and all preemergence herbicides applied after planting. Postemergence herbicides were applied at various weed stages for the initial application and as needed in the second application for each treatment. At the time of the postemergence application following preemergence herbicides the rank of effectiveness of the preemergence herbicides were as follows: saflufenacil plus dimethenamid (Verdict) plus pyroxasulfone, saflufenacil plus pyroxasulfone, metribuzin plus s-metolachlor (Boundary), fomesafen plus s-metolachlor (Prefix), flumioxazin plus metribuzin, and flumioxazin plus pyroxasulfone (Fierce) controlled 95, 94, 89, 87, 77, and 69% glyphosate-resistant waterhemp, respectively and flumioxazin plus metribuzin, saflufenacil plus dimethenamid (Verdict) plus pyroxasulfone, saflufenacil plus pyroxasulfone, saflufenacil plus pyroxasulfone, fomesafen plus s-metolachlor (Prefix), and flumioxazin plus pyroxasulfone (Fierce) controlled 77, 69, 69, 65, 56, and 48% glyphosate-resistant common ragweed, respectively. Just before harvest at Holloway, MN, all treatments in glufosinate-resistant soybean controlled 96% of glyphosate-resistant waterhemp compared to all treatments in glyphosate-resistant soybean controlling 89% of glyphosate-resistant waterhemp. Just before harvest at Buxton, ND, all treatments in glufosinate-resistant soybean controlled 98% of glyphosate-resistant common ragweed compared to all treatments in glyphosate-resistant soybean controlling 79% of glyphosate-resistant common ragweed. The herbicide program ranking for control of glyphosate-resistant waterhemp was as follows: preemergence followed by glufosinate plus an acetamide herbicide plus an additional postemergence herbicide (99%), preemergence followed by glufosinate plus an additional postemergence herbicide (99%), glufosinate alone (99%), glufosinate plus an additional postemergence herbicide (98%), glufosinate applied early postemergence plus an acetamide herbicide and plus an additional postemergence herbicide (97%), and preemergence followed by glufosinate alone (93%) for glufosinate-resistant soybean and preemergence followed by glyphosate alone (94%), preemergence followed by glyphosate plus an additional postemergence herbicide (93%), preemergence followed by glyphosate plus an acetamide herbicide plus an additional postemergence herbicide (91%), glyphosate plus an additional postemergence herbicide (90%), glyphosate alone (75%), and glyphosate applied early postemergence plus an acetamide herbicide and plus an additional postemergence herbicide (71%) for glyphosate-resistant soybean. The herbicide program ranking for control of glyphosate-resistant common ragweed was as follows: preemergence followed by glufosinate plus an acetamide herbicide plus an additional postemergence herbicide glyphosate (99%), preemergence followed by glufosinate plus an additional postemergence herbicide (99%), preemergence followed by glufosinate alone (99%), glufosinate plus an additional postemergence herbicide (97%), glufosinate alone (97%), and glufosinate applied early postemergence plus an acetamide herbicide and plus an additional postemergence herbicide (97%) for glufosinate-resistant soybean and preemergence followed by glyphosate plus an acetamide herbicide plus an additional postemergence herbicide (99%), preemergence followed by glyphosate plus an additional postemergence herbicide (95%), preemergence followed by glyphosate alone (78%), glyphosate plus an additional postemergence herbicide (73%), glyphosate applied early postemergence plus an acetamide herbicide and plus an additional postemergence herbicide (68%), and glyphosate alone (58%) for glyphosate-resistant soybean. At Holloway, MN the glyphosate-resistant soybean out-yielded the glufosinate-resistant soybean across all treatments 2529 to 1917 kg/ha. At Buxton, ND the glufosinate-resistant soybean out-yielded the glyphosate-resistant soybean across all treatments 733 to 659 kg/ha.

SYSTEMS FOR MANAGEMENT OF GLYPHOSATE-RESISTANT HORSEWEED IN SOYBEANS. Bryan Reeb*, Mark M. Loux, Anthony Dobbels; The Ohio State University, Columbus, OH (112)

Two field studies were conducted in west central Ohio to determine the benefits of a system-type approach to management of glyphosate-resistant/ALS-sensitive horseweed in no-tillage soybeans. The first study, conducted with glufosinate-resistant soybeans, included all possible combinations of several different fall and spring herbicide treatments, followed by postemergence application of glufosinate. The second study, conducted with glyphosate-resistant soybeans, included several different types of single or sequential herbicide treatments applied in the spring only. These were followed by a postemergence application of glyphosate. The fall/spring study was conducted in 2010, 2011, and 2012, while 2012 was the first year for the spring-only study. In the fall/spring study, most effective control in early June, just prior to the postemergence glufosinate application, occurred with treatments that included fall application of chlorimuron and/or spring application of flumioxazin and chlorimuron. Any treatment where the combination of glyphosate, 2,4-D, chlorimuron and flumioxazin was applied in late April resulted in greater than 90% control in early June, averaged over years. Otherwise, obtaining this level of control required fall application of chlorimuron and 2,4-D, followed by spring application of additional nonselective and residual herbicides. The postemergence glufosinate application provided enough additional horseweed control to improve late-season control to at least 80% for all treatments. However, the previously mentioned treatments were among the most effective for late-season control as well, especially in a year where the postemergence glufosinate activity was reduced or soybean development was hindered by adverse weather. These treatments reduced late-season population density to less than 1 plant/m^2, averaged over years, while the density otherwise ranged from 1 to 10 plants/m^2. In the spring-only study, horseweed control at the time of postemergence glyphosate application exceeded 90% for metribuzin-containing treatments only. These included early-April application of glyphosate, 2,4-D and metribuzin (0.42 or 0.63 kg ai/ha), late-April application of glyphosate, 2,4-D and metribuzin (0.63 kg/ha only), and a sequential-application treatment consisting of glyphosate, 2,4-D and metribuzin (0.21 kg/ha) in early April, followed by glufosinate and metribuzin (0.32 kg/ha) in early May at the time of soybean planting. Similar treatments where the metribuzin was replaced by flumioxazin, sulfentrazone, or flumioxazin plus chlorimuron controlled less than 70% of the horseweed at the time of postemergence glyphosate application. These trends were also evident for the preharvest measurements. The lowest preharvest horseweed population densities, less than 0.5 plants/m^2, occurred for the combination of glyphosate, 2,4-D, and metribuzin. This occurred only for the higher metribuzin rate of 0.63 kg/ha applied in early or late April, or where metribuzin was applied at both timings for a total rate of 0.52 kg/ha. The preharvest population density ranged from 5.7 to 11 plants/m^2 among other treatments. The spring study will be repeated in 2013 and 2014.

GLYPHOSATE RESISTANT CANADA FLEABANE (*CONYZA CANADENSIS*) IN ONTARIO: DISTRIBUTION AND CONTROL IN SOYBEAN (*GLYCINE MAX L.*). Holly P. Byker*[1], Peter Sikkema[2], François Tardif[3], Darren E. Robinson[4], Mark Lawton[5]; [1]University of Guelph, Ridgetown Campus, Ridgetown, ON, [2]University of Guelph - Ridgetown Campus, Ridgetown, ON, [3]University of Guelph, Guelph, ON, [4]University of Guelph, Ridgetown, ON, [5]Monsanto Canada, Guelph, ON (113)

Canada fleabane is a genetically diverse weed which adapts to no till and Roundup Ready soybean agricultural practices, disbursing easily via windblown seed.Â In 2010, populations of Canada fleabane were confirmed to be resistant to glyphosate at 8 locations in Essex County in Ontario. Â Seeds from Canada fleabane were collected in the fall of 2011 and an additional 76 resistant populations were identified as glyphosate resistant (GR) within the counties of Essex (48), Kent (19), Elgin (7), Lambton (1), and Niagara (1). Â Four field trials in Roundup Ready soybeans were conducted in 2011 and 2012 at sites with confirmed GR Canada fleabane. Â The objectives of these trials were a) to determine the biologically effective rate of glyphosate on these resistant populations, b) to evaluate glyphosate tankmixes for the control of GR Canada fleabane, and c) to determine the efficacy of dicamba for the control of GR Canada fleabane in dicamba-resistant soybean (Roundup Ready 2 Extend soybean). Â Saflufenacil, saflufenacil/dimethenamid-p, metribuzin, and flumetsulam tankmixed with glyphosate provided greater than 90% control of GR Canada fleabane. Â None of the post-emergence tankmixes provided acceptable control of GR Canada fleabane. Â Dicamba was found to be a very effective herbicide for control for of GR Canada fleabane in a fifth trial established in confined trials with Roundup Ready 2 Extend soybean.

COMPARING FARMER AND UNIVERSITY PRACTICES FOR CONTROLLING GIANT RAGWEED. JD Bethel*[1], Mark M. Loux[1], Steve Prochaska[2]; [1]The Ohio State University, Columbus, OH, [2]The Ohio State University, Marion, OH (114)

Studies were conducted at a total of 6 sites in 2011 and 2012 to determine the effectiveness of POST herbicide strategies for control of giant ragweed in glyphosate-resistant soybeans. Studies were located in fields where growers had concerns that giant ragweed biotypes were exhibiting low levels of glyphosate resistance. The objectives of the study were to: 1) compare an aggressive POST glyphosate-only strategy with the growers' POST glyphosate management; and 2) determine if POST applications of glyphosate with an effective partner herbicide were more effective than POST applications containing only glyphosate. Growers were allowed to perform preplant tillage and herbicide applications of their choosing. POST treatments consisted of: 1) glyphosate at 1.7 kg ae/ha; 2) glyphosate at 1.7 kg/ha plus fomesafen at 0.35 kg ai/ha; 3) glyphosate at 1.7 kg/ha followed by (fb) glyphosate at 0.84 kg/ha; and 4) glyphosate at 1.7 kg/ha plus fomesafen at 0.35 kg ai/ha fb glyphosate at 0.84 kg/ha plus lactofen at 0.2 kg ai/ha. All treatments were applied with ammonium sulfate and the treatments containing fomesafen or lactofen also included methylated seed oil or crop oil concentrate, respectively. The initial POST treatment was applied when giant ragweed plants were 10 to 15 cm tall, and the second POST treatment was applied three weeks later. Growers typically applied glyphosate alone once at 0.84 to 1.12 kg/ha, and this occurred 6 to 12 days after the first university POST treatment. Efficacy was determined through visual evaluation of control and the mortality of 20 giant ragweed plants within each plot, which were flagged prior to initial POST treatment. In 2012, the effect of treatment on fecundity was measured by collecting and enumerating seed from surviving plants at the end of the season. In 2011, treatments with two POST herbicide applications resulted in 97% control of giant ragweed at harvest, compared with 80 to 84% control for single-application treatments. All university treatments provided higher levels of control then the growers' programs. In 2012, the two-application treatments provided more effective control of giant ragweed than single-application treatments at two of three sites. Mortality of giant ragweed after the initial POST treatment was higher for the combination of glyphosate and fomesafen compared to glyphosate alone, averaged over all sites, but there were no differences between one- and two-application treatments at the end of the season. Differences in fecundity among treatments occurred at only one site in 2012. The two-application treatments reduced fecundity more than a single application, due primarily to the latter's inability to effectively control late-emerging weeds.

COSTS AND BENEFITS OF ESTABLISHING ALFALFA WITH GLYPHOSATE ACROSS SEVEN PRODUCTION FIELDS IN WISCONSIN. Mark J. Renz*; University of Wisconsin Madison, Madison, WI (115)

Weeds can reduce alfalfa plant density, yield and forage quality in the establishment year. Consequently, weed suppression is important during establishment of alfalfa. Applications of POST herbicides are typically recommended when weed species are small (< 8 cm tall) to minimize these impacts, but the potential for later applications now exist when using Roundup Ready alfalfa as glyphosate is labeled for use on taller weeds. This study evaluated effectiveness of glyphosate compared to imazamox in weed control, alfalfa forage yield, and stand density when applied to small versus to larger weed species. Research was conducted in fields planted to Roundup Ready alfalfa across seven production farms in Wisconsin to evaluate the differences between treatments and an untreated control. A randomized complete block design with three replications was utilized in Dane, Fond du Lac, Jackson, Clark, Brown, Door, and Washburn counties in Wisconsin. Treatments consisted of glyphosate (841 g ae ha^{-1}) or imazamox (44 g ae ha^{-1}) applied when weeds were small (< 8 cm) compared to 2-3 weeks later (weeds were 12-30 cm in height). Common lambsquarter control was superior with glyphosate when applied to small weeds (> 95% control). Imazamox provided reduced control compared to glyphosate applications with small weeds. No differences in control were observed between timing of application within active ingredients. Percentage of alfalfa in the first harvest was maximized with glyphosate applied to small weeds, but delaying applications reduced the percentage of alfalfa by 21%. Imazamox improved the percentage of alfalfa in the first harvest compared to untreated plots, but no differences between timings were observed. Results across locations suggest that timing of herbicide application with either glyphosate or imazamox is not important for improved weed control and applications to small weeds only improved the percentage of alfalfa in the first cutting with glyphosate compared to other herbicide treatments. However analysis of locations separately demonstrates the benefit of application timing as fields with high weed biomass had the greatest lambsquarter control and percentage alfalfa in the first harvest when applied to small weeds regardless of active ingredient.

FALL WEED MANAGEMENT TO LIMIT SCN POPULATION BUILD-UP. Rodrigo Werle*[1], Mark L. Bernards[2], Loren J. Giesler[1], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Western Illinois University, Macomb, IL (116)

Soybean cyst nematode (SCN) is the most yield limiting disease of soybeans in the United States. Henbit is a prevalent winter annual weed species in no-till fields and is reported to be an alternative host of SCN. A greenhouse study was conducted to evaluate how the development of SCN on henbit roots was affected by herbicide mode of action and time of application. Ten days after transplanting henbit seedlings in pots filled with 750 ml of sterilized soil, 1,000 SCN eggs were inoculated in each pot. At 7, 14, and 21 days after inoculation (DAI), henbit plants were sprayed with recommended doses of either glyphosate or 2,4-D. At 28 DAI, the total number of SCN cysts and eggs, and plant shoot and root dry weights per pot were determined. Henbit root and shoot biomass increased as the time of application was delayed. Glyphosate reduced root biomass more than 2,4-D, but no differences in shoot biomass were detected. The number of SCN cysts per plant and eggs per cyst increased as the application time was delayed from 7 to 21 DAI. Glyphosate reduced the number of cysts found on henbit roots more than 2,4-D, especially at earlier application times. On plants treated with glyphosate, SCN-females produced only half the number of eggs of SCN-females on plants treated with 2,4-D, regardless of time of application. These results indicate that the early control of henbit plants, especially with glyphosate, may reduce SCN reproduction potential in SCN infested fields. In a side field study conducted at 8 locations in Nebraska, the majority of the henbit seedlings (>95 %) emerged by end-October/mid-November, indicating that henbit control after crop harvest in the North Central region of the USA would be the ideal time to manage this weed and consequently reduce potential SCN reproduction.

CAN SOIL-RESIDUAL PROTOPORPHYRINOGEN OXIDASE (PPO)-INHIBITING HERBICIDES INFLUENCE THE FREQUENCY OF PPO-RESISTANT WATERHEMP? R. Joseph Wuerffel*, Bryan G. Young, Julie M. Young, Joesph L. Matthews; Southern Illinois University, Carbondale, IL (117)

Common waterhemp (*Amaranthus tuberculatus*) resistant to PPO-inhibiting herbicides has become increasingly important now that infestations of glyphosate-resistant populations of this species are prevalent in the Midwestern U.S. Thus far, waterhemp plants classified as PPO-resistant (R-biotype) can withstand foliar applications of PPO-inhibiting herbicides while soil residual herbicides within this mode of action maintain commercial levels of herbicide efficacy. Common theory would suggest that soil residual PPO-inhibiting herbicides would select for the R-biotype as herbicide concentrations dissipate in the soil, but this phenomenon has never been demonstrated. Thus, the objectives of this research were to determine if PRE applications of PPO-inhibiting herbicides will select for the R-biotype, and if the selection for resistance will impact the frequency of PPO resistance in surviving waterhemp populations. Greenhouse experiments demonstrated that PRE applications of PPO-inhibiting herbicides, with and without the influence of soil, can select for the R-biotype, as significant differences in sensitivity were detected between R- and S-biotypes. Consequences of the observed selection were realized in field experiments conducted in Clinton and Jackson Co., IL, in fields containing mixed populations of PPO-R and -S waterhemp. Following PRE applications of fomesafen, tissue samples were collected from surviving waterhemp plants at each site and analyzed using a PCR assay to confirm PPO resistance. The resulting shift in the waterhemp population towards a higher frequency of the R-biotype in treated plots demonstrated the selection from soil residual PPO-inhibiting herbicides in commercial field populations. Overall, this research further reinforces the importance of proper weed management that utilizes multiple, effective modes of action and full herbicide use rates in PRE applications.

PREEMERGENCE AND POSTEMERGENCE CONTROL OF AMARANTHUS SPECIES WITH LACTOFEN ALONE AND IN COMBINATION WITH V-10206.

Trevor M. Dale*[1], Eric J. Ott[2], John A. Pawlak[3], Dawn Refsell[4]; [1]Valent USA Corporation, Plymouth, MN, [2]Valent USA Corporation, Greenfield, IN, [3]Valent USA Corporation, Lansing, MI, [4]Valent USA, Lathrop, MO (119)

Weed resistance to glyphosate continues to expand both geographically and new species confirmations have continued throughout the major corn and soybean producing states. With the spread of glyphosate resistant weeds, weed control programs have become more complex and growers across of the US have adopted the use of preemergence herbicides, the use of additional postemergence herbicides, row crop cultivation, and in certain areas hand weeding. The most significant resistant weed species in the US is glyphosate resistant Palmer amaranth. Glyphosate resistant Palmer amaranth causes millions of dollars in crop losses each year in many Southern states and has recently been documented in Indiana and Michigan. Replicated trials were established to evaluate the control of amaranthus species, common ragweed, and giant ragweed throughout the Mid-west and Southern areas of the US. The objective of these studies was to evaluate lactofen applied at 0.156 and 0.188 lb ai/a applied alone and in combination with V-10206 at 0.08 and 0.096 lb ai/a for postemergence and preemergence residual control of certain glyphosate resistant weeds. The standard utilized for comparison purposes was fomesafen at 0.206 lb ai/a plus s-metolachlor at 0.78 lb ai/a. Treatments were applied when the average weed size was 5 – 10 cm and compared to applications at 10 – 15 cm weed sizes.

RESPONSE OF AMUR HONEYSUCKLE (*LONICERA MAACKII*) TO POSTEMERGENCE HERBICIDES.

Spencer A. Riley*, Reid J. Smeda; University of Missouri, Columbia, MO (120)

Amur honeysuckle *(Lonicera maackii)* is a highly invasive shrub throughout the Central and Northeast U.S. Plants persist in undisturbed areas along treelines. Although widespread, there are relatively few reports on response to herbicides. The objective of this research was to determine herbicide efficacy on Amur honeysuckle using foliar (summer) and basal bark (fall, spring) applications. Foliar trials were established in Moberly and Columbia, MO in June and July, 2011 and Moberly and Ashland, MO in July, 2012. Plants had been mowed to 10 cm the previous fall to allow uniform coverage of foliage. In late June to early July when plants reached 1 m in height, combinations of amino acid biosynthesis inhibitors (glyphosate, imazapyr, metsulfuron-methyl) and growth regulators (dicamba, fluroxypyr, triclopyr, picloram, aminocyclopyrachlor, and 2,4-D) were applied with appropriate adjuvants using a backpack sprayer which delivered 373 L/ha; an untreated control was also included. Experimental design was a randomized complete block with five replications. Visual injury ratings (0 = no control, 100 = plant death) were recorded at 28, 90, and 120 days after treatment (DAT). Development of injury symptoms was slow; only aminocyclopyrachlor + metsulfuron-methyl + imazapyr resulted in >90% control at 28 DAT across all site years. All other treatments exhibited varying control (16 to 92%), with the lowest control recorded for picloram + fluroxypyr (16%). Treatment efficacy improved by 90 DAT; aminocyclopyrachlor + metsulfuron-methyl + imazapyr, and aminocyclopyrachlor + metsulfuron-methyl resulted in excellent control (>90%); glyphosate exhibited good control (78 to 99%). By 120 DAT, aminocyclopyrachlor + metsulfuron-methyl + imazapyr, aminocyclopyrachlor + metsulfuron-methyl, and glyphosate exhibited >95% control. Control in other treatments varied from 12 to 92%. Trials for basal bark applications were established at two locations near Columbia for fall and spring applications. Treatments included triclopyr, triclopyr + fluroxypyr, and glyphosate as undiluted formulated herbicide, as well as herbicides in basal blue oil; imazapyr and aminocyclopyrachlor. Applications were made at 9 mL $stem^{-1}$ $bush^{-1}$ from ground level to 45 cm up the stem. Visual injury ratings were recorded monthly from June through November of 2012. For all fall applications, efficacy did not exceed 25% up to 11 months after treatment (MAT). For spring applications, >50% control was observed for aminocyclopyrachlor at 5 (MAT), with all other treatments resulting in up to 35% control. Results suggest that several herbicide options exist for foliar control of Amur honeysuckle, but plant response is slow. Basal bark applications do not appear an effective method to control plants.

COMPETITIVE EFFECTS OF AN INVASIVE AMARANTHACEAE (*ACHYRANTHES JAPONICA*) ON SOYBEAN COMPARED WITH *AMARANTHUS PALMERI* AND *A. RUDIS*. Lauren M. Schwartz*[1], Bryan G. Young[1], David J. Gibson[2]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois Univeristy, Carbondale, IL (121)

Historically, some of the most problematic weeds found in the Midwest United States are found in the Amaranthaceae family, such as *Amaranthus palmeri* and *A. rudis*. These summer annual weeds are problematic to agricultural crops (i.e. soybean and corn) due to their competitive ability, high seed production, and tolerance/resistance to several herbicide modes of action; which ultimately leads to yield loss. *Achyranthes japonica* (Japanese chaff flower) is an invasive, exotic species within this family. This perennial, herbaceous species has quickly spread along the Ohio River and tributaries since its apparent introduction from Eastern Asian in the 1980s and is currently found in nine states. *Achyranthes japonica* is typically found in areas with partial sun and moist soils, and can grow in heavily shaded and drier environments. It is found in bottomland forests, riverbeds, field edges and ditches, including crop margins. The competitive ability of *A. japonica* on soybean when compared with *A. palmeri* and *A. rudis* was studied in a controlled field experiment. Pots were placed into the ground and each weed species was grown at varying densities of 1, 2, 4, or 8 seedlings grown from seed in each pot in the presence of absence of soybeans. Response variables (height, number of nodes, number of leaves, number of stems, and biomass) and a resource (light intensity) were measured over 33 days. It should be noted that not all of the *A. japonica* densities were reached during this experiment. During the experiment, the performance of the Amaranthaceae species were differentially affected by the presence or absence of soybeans and by weed species density (P=0.0055). The soybeans did not show any significant differences in response variables or to the resource measured. The weed species, density, and day after planting affected all of the response variables except for biomass. Biomass varied among weed species and the density at which sown for both aboveground (P=0.0096) and belowground (P=0.0047). *Amaranthus palmeri* showed the most competitive ability when interacting with the soybeans in comparison to the other Amaranthaceae species. *Achyranthes japonica* did not readily compete with soybeans, which could be due to several environmental factors.

THREE YEARS OF TESTING ILLINOIS WATERHEMP POPULATIONS FOR MULTIPLE RESISTANCE TO GLYPHOSATE, PPO INHIBITORS, AND ALS INHIBITORS. Chance Riggins*[1], Aaron G. Hager[2], Patrick Tranel[2]; [1]University of Illinois Urbana Champaign, Urbana, IL, [2]University of Illinois, Urbana, IL (122)

During the growing seasons of 2010, 2011, and 2012, waterhemp (*Amaranthus tuberculatus*) populations from across Illinois and several adjacent states were surveyed for resistances to three major herbicide classes (ALS inhibitors, PPO inhibitors, and glyphosate) using molecular assays. All plant samples were acquired from growers and weed management clientele by solicitation, and most samples were from populations suspected to be resistant to glyphosate. Molecular assays were performed on individual plants, which allowed for the simultaneous detection of resistant biotypes and multi-resistant individuals. Results from 2010 and 2011 confirmed our expectations that ALS resistance was widespread and present in most fields and, therefore, we opted to test for resistance only to PPO-inhibitors and glyphosate during the 2012 survey. Over the three years, more than 900 plants from over 200 fields were tested. The majority of fields was from Illinois, with 46 counties represented, followed by Iowa (8 counties), Kentucky (2 counties), Indiana (1 county), and Minnesota (1 county). Results from 2012 agreed with those from prior years in that at least two-thirds of the fields tested positive for glyphosate-resistant waterhemp. Furthermore, the 2012 data revealed that 14% of the fields with glyphosate resistance also tested positive for PPO-resistance, which was similar to observations in 2010 and 2011. Over the three years, PPO-resistance also was confirmed in nineteen of twenty-one additional fields that were suspected of having PPO-resistant waterhemp. The results of our multi-year survey illustrate the growing problem of multiple herbicide resistance in Midwestern waterhemp populations and the need for new herbicides and/or weed management strategies.

INFLUENCE OF NITROGEN APPLICATION TIMING ON THE ACTIVITY OF MESOTRIONE APPLIED FOR LARGE CRABGRASS CONTROL. Quincy D. Law*[1], Dan V. Weisenberger[2], Aaron J. Patton[1]; [1]Purdue University, W. Lafayette, IN, [2]Purdue University, Lafayette, IN (123)

Mesotrione, a 4-hydroxyphenylpyruvate dioxygenase (HPPD) inhibiting herbicide labeled for preemergence and postemergence control of numerous grassy and broadleaf weeds, has enhanced efficacy on smooth crabgrass (*Digitaria ischaemum*) when applied in conjunction with soil-applied nitrogen (N). Our objective was to determine if N application timing influences the activity of mesotrione and its control of large crabgrass (*Digitaria sanguinalis).* A greenhouse experiment designed as a randomized complete block with 10 treatments and six replications was conducted twice in 2012. The nine primary treatments included applications of N at 49 kg ha^{-1} applied at 14, 7, 3, and 1 day before mesotrione application (DBA), immediately before mesotrione application, and 1, 3, 7, and 14 days after mesotrione application (DAA). An untreated check was also fertilized the day of herbicide application, but it did not receive herbicide. Nitrogen treatments were soil-applied to each pot using 20 mL of water solution containing urea (46N-0P-0K) to deliver 49 kg ha^{-1}, and mesotrione was applied at 175 g ha^{-1}. At the time of the mesotrione application, plants were in the 3-5 leaf stage except for the 7 and 14 DBA treatments which ranged from 4-leaf to 2-tiller in size. Counts of healthy, bleached, and necrotic leaves were taken one, two, and three weeks after herbicide application and used to determine the percentage of green, bleached, and necrotic leaves, respectively. Aboveground tissue was also harvested, dried, and weighed three weeks after herbicide application. Results were similar between experimental runs. Large crabgrass plants that received N three days prior to the mesotrione application had the highest percentage of bleached leaves followed by treatments receiving N one day prior and the day of herbicide application when measured three weeks after herbicide application (Fig. 1). The number of bleached leaves was >20% more in the 3 DBA N timing compared to N applied 14 DBA or N applied 14 DAA. These results indicate that N fertilization prior to mesotrione application may improve large crabgrass control but the exact causal mechanism of enhanced herbicide activity needs further exploration.

PREEMERGENCE HERBICIDES AFFECT HYBRID BERMUDAGRASS NUTRIENT CONTENT. Patrick A. Jones*[1], James Brosnan[2], Dean A. Kopsell[3], Gregory K. Breeden[2]; [1]University of Tennessee Knoxville, Knoxville, TN, [2]University of Tennessee, Knoxville, TN, [3]The University of Tennessee, Knoxville, TN (124)

Preemergence herbicides negatively impacting turfgrass root development may reduce nutrient accumulation in foliar tissue. Research was conducted in 2012 to determine the effects of indaziflam (35 and 52.5 g ha^{-1}), prodiamine (0.84 kg ha^{-1}), oxadiazon (3.36 kg ha^{-1}), and isoxaben (1.12 kg ha^{-1}) applications on hybrid bermudagrass [*C. dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy] tissue nutrient content. Hybrid bermudagrass was transplanted from washed sod into polyethylene containers filled with 10 L of Hoagland's nutrient solution, where plants were allowed to acclimate for three weeks prior to herbicide treatment. Visual foliar injury (i.e., curling of new growth, reddening of leaf tissue, necrosis) was rated on a percent scale, relative to an untreated control, from 0 (no injury) to 100 (plant death). Root color as well as root mass were visually assessed weekly on a 1 (brown/black roots, lower mass, respectively) to 5 (white roots, greater mass, respectively) scale. Foliar and root biomass were also harvested at the conclusion of the study, dried, and weighed. Foliar tissue harvested was analyzed for macro- and micronutrient content. Significant foliar injury (72% and 78% in experimental run one and run two, respectively) was observed in both experimental runs with both rates of indaziflam with no significant difference being detected between the two rates. Prodiamine, indaziflam, and isoxaben reduced visual root mass and root color relative to non-treated plants. These reductions were concomitant with reduced P, S, and K content in foliar tissue. Treatment with indaziflam reduced Mg and Mn content in foliar tissue compared to non-treated plants. This response was not observed with prodiamine and could explain the significant foliar injury (>70%) observed with both rates of indaziflam in this research. Data from this study suggest that preemergence herbicide applications affect hybrid bermudagrass nutrient content.

ROOT COLONIZATION OF GLYPHOSATE-TREATED WEED BIOTYPES BY SOIL MICROBES. Jessica R. Schafer*^{1}, Steven G. Hallett^2, William G. Johnson^2; ^{1}Purdue Univeristy, West Lafayette, IN, ^{2}Purdue University, West Lafayette, IN (125)

Root colonization by soil microorganisms has been shown to increase the activity of glyphosate in resistant, tolerant, and susceptible biotypes of giant ragweed and common lambsquarters; but not in horseweed biotypes. The objective of this study was to investigate the colonization of roots in glyphosate-resistant and -susceptible giant ragweed and horseweed biotypes, and glyphosate-tolerant and -susceptible biotypes of common lambsquarters after a sublethal glyphosate application. The three weed species were grown separately in sterile and unsterile field soil and treated with glyphosate at two sublethal rates. Soil microbes were isolated from the roots onto sterile media three days after the glyphosate treatment. The susceptible biotypes of giant ragweed and horseweed grown in unsterile soil were colonized by more soil microbes at the higher rate of glyphosate, compared to the resistant biotype grown in unsterile soil. Oomycetes were isolated separately on a selective medium and they were also more prevalent in the roots of the susceptible biotypes of each weed species grown in the unsterile soil when glyphosate was applied at the highest rate. Therefore, the ability of these three weed species to tolerate a glyphosate application may involve differences in the susceptibility to soil microbial colonization, especially oomycetes. These findings also suggest that plant tolerance to soil microbes is associated with the evolution of resistance to glyphosate.

EFFECTS OF HERBICIDE APPLICATION TIMING AND OVERSEEDING ON DALLISGRASS (*PASPALUM DILATATUM*) CONTROL IN TALL FESCUE (*FESTUCA ARUNDINACEA*). Matthew T. Elmore*, James Brosnan, Gregory K. Breeden; University of Tennessee, Knoxville, TN (126)

Dallisgrass (*Paspalum dilatatum*) is a perennial warm-season grassy weed found throughout much of the southern United States. Selective control of dallisgrass in tall fescue (*Festuca arundinacea*) is difficult. Previous reports indicate efficacy of the ACCase-inhibiting herbicide fluazifop-*p*-butyl (fluazifop) varies with seasonal application timing, but more investigation is warranted. Additionally, the HPPD-inhibiting herbicides mesotrione, topramezone and tembotrione are being researched for use in turfgrass and may have dallisgrass activity. In 2010 and 2011 field experiments evaluated fluazifop (105 g ha^{-1}) alone or in combination with mesotrione (280 g ha^{-1}), topramezone (37 g ha^{-1}) and tembotrione (92 g ha^{-1}) applied at different growing degree day- (GDD) or cooling degree day- (CDD) based application timings. GDD's were calculated using a 10 °C base beginning January 1. CDD's were calculated by subtracting the average daily temperature from a 22 °C base beginning July 1. The influence of fall or spring tall fescue interseeding was also evaluated. Herbicide treatments were applied through flat-fan nozzles with NIS at 0.25% v/v and 280 L ha^{-1} of water using standard CO_2-powered small-plot spray equipment. Interseeding treatments were applied using a slit-seeder at 353 kg pure live seed per hectare. The irrigated experiment site contained a natural dallisgrass infestation and was maintained at a 10-cm height of cut with a rotary mower. Plots were arranged in a split-split plot randomized complete block design with three replications. Dallisgrass control and tall fescue injury were evaluated 2, 4, 8, 18, and 52 weeks after treatment (WAT). Grid counts were conducted 52 WAT for a quantitative assessment of dallisgrass control. Fluazifop applied at 175 GDD and 5 CDD provided the greatest control 52 WAT in 2010; application at 5 CDD provided greater dallisgrass control than treatments applied at 75, 375 and 775 GDD at 8 and 18 WAT in 2011 as well. Combining HPPD-inhibitors with fluazifop did not improve control compared to fluazifop alone in either year. Application of mesotrione alone provided < 20% dallisgrass control regardless of application timing or rating date. Tembotrione and topramezone controlled dallisgrass < 65% regardless of application timing or rating date. Fall interseeding improved dallisgass control 52 WAT from herbicide treatments applied at 175, 375 and 775 GDD in 2010 and at 75, 175, 375 and 775 GDD in 2011. Spring interseeding did not improve dallisgrass control. Data suggest fluazifop applications at 175 GDD and 5 CDD and fall interseeding will provide the greatest dallisgrass control with minimal tall fescue injury. Future research should investigate GDD and CDD-based herbicide application timings in other locations in order to develop programs for dallisgrass control using GDD and CDD-based application timings.

VOLUNTEER CORN REDUCES YIELD IN SUGARBEET. Christy Sprague, Amanda C. Harden*; Michigan State University, East Lansing, MI (127)

Glyphosate-resistant volunteer corn continues to be a problem in glyphosate-resistant sugarbeet. While there are effective strategies to help manage this problem, many growers do not understand the effects volunteer corn has on sugarbeet yield and sucrose quality. Therefore, they do not implement these strategies. Field trials were conducted in 2012 at the Michigan State University Agronomy Farm in East Lansing and at the Saginaw Valley Research and Extension Center near Richville, Michigan. The objectives of this research were to: 1) quantify the effects of volunteer glyphosate-resistant corn on glyphosate-resistant sugarbeet yield and sucrose quality, and 2) determine the effects of row-width on volunteer corn interference in sugarbeet. Glyphosate-resistant 'HM 9173 RR' was planted at 124,000 plants ha^{-1} in 38- and 76-cm rows. At the time of planting, F2 glyphosate-resistant corn seed was planted approximately 5-cm off the sugarbeet row at populations of 0; 1,080; 2,150; 4,310; 8,610; and 17,220 plants ha^{-1}. Sugarbeet canopy closure in the 38- and 76-cm row widths was evaluated throughout the season. At the end of the season, volunteer corn biomass was harvested and weighed. Sugarbeet were harvested to determine yield, sucrose content, and quality. The sugarbeet canopy developed quicker in 38- than in 76-cm rows. Sugarbeet in 38-cm rows were also able to compete more effectively with volunteer corn than sugarbeet planted in 76-cm rows. This year under drought conditions, it appeared that sugarbeet was able to compete more effectively with volunteer corn and was able to withstand volunteer corn populations up to 4,310 plants ha^{-1}. This may not always be the case under different environmental conditions where moisture may be more available. This research will be repeated in 2013.

INVESTIGATIONS INTO *AMBROSIA ARTEMISIIFOLIA* (COMMON RAGWEED) GLYPHOSATE RESISTANCE MECHANISMS. Jason T. Parrish*[1], Mark M. Loux[1], Philip Westra[2], Andrew Wiersma[3], Christopher Van Horn[3], David Mackey[1], Leah McHale[1]; [1]The Ohio State University, Columbus, OH, [2]Colorado State University, Fort Collins, CO, [3]Colorado State University, Ft. Collins, CO (129)

Common ragweed (*Ambrosia artemisiifolia*) is an almost ubiquitous weed throughout Ohio, and can cause considerable yield loss when competing with crops. Common ragweed is typically well-controlled in soybeans with various herbicide programs, but is becoming a larger concern as options are reduced due to the evolution of herbicide-resistant biotypes. The molecular basis for glyphosate-resistance in Ohio common ragweed populations is unclear. Our current research seeks to elucidate potential mechanism(s) of resistance, through studies of expression and sensitivity of the target enzyme for glyphosate, 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). Sequence analysis of *epsps* gene PCR products does not show any target-site mutations in samples from glyphosate-resistant populations, in comparison to "wild-type" glyphosate-sensitive plants. This sequence also demonstrates that there are 2 or more copies of *epsps* in common ragweed. An immunoblot assay with common ragweed total soluble protein, as well as Palmer amaranth (*Amaranthus palmeri*) and kochia (*Kochia scoparia*) controls, was inconclusive in that no EPSPS expression could be detected except in the Palmer amaranth and kochia over-expressing controls. Current research focuses on *epsps* genomic and mRNA transcript copy numbers.

DIFFERENTIAL ROOT AND SHOOT UPTAKE OF FLUMIOXAZIN AND PUROXASULFONE IN THREE PLANT SPECIES. Dawn Refsell*[1], Anita Dille[2]; [1]Valent USA, Lathrop, MO, [2]Kansas State University, Manhattan, KS (130)

Flumioxazin is currently registered and labeled for preemergence weed control in corn, soybean and wheat. Pyroxasulfone is a new preemergence herbicide that will be potentially registered in soybean and wheat and is currently registered for use in reduced tillage corn for the control of many broadleaf and grass weeds. Our hypothesis was that flumioxazin affected the roots of plants, while pyroxasulfone would affect the shoots; there for a combination product would have different physical sites of action affecting both the root and shoot of germinating weeds. Objective of the study was to determine the extent of injury based on localized herbicide exposure to roots, shoots, and to both roots and shoots utilizing a novel technique. Herbicides evaluated included flumioxazin, pyroxasulfone, and the combination as Fierce (flumioxazin + pyroxasulfone). Field use rates studied were flumioxazin at 0.063 lb ai/A and pyroxasulfone at 0.079 lb ai/A. Two weed species including tall morningglory and shattercane, in addition to the crop wheat, were evaluated for injury based upon root and shoot exposure. Weeds were exposed to 0.25, 0.5 and 1x field use rates, whereas wheat exposure was at 1, 2, and 4x rate. Weed and crop seed were germinated in silica sand in greenhouse to approximately 5 to 10 cm shoot growth. (Three to five seedlings were then transferred into each specially designed two-petri dish combination to physically limit plant exposure, that is a root half and a shoot half. Each half of the dish combination was filled with 125 g of silica sand and then filled with 30 ml of water or herbicide treatment. The herbicide treatments included none (30 ml water), shoot exposure only, root exposure only, or both shoot + root exposure. Each herbicide by species combination was replicated at least six times. Petri-dishes were placed in growth chambers where the conditions were 24°C with a 24H photoperiod. Flumioxazin treatments were evaluated after 48 hours, whereas the pyroxasulfone and flumioxazin + pyroxasulfone treatments were evaluated after 72 hours. Each dish was examined to determine the number injured or dead per dish combination. This was then converted to a % affected plants per treatment. Data were analyzed utilizing SAS and separated by LSMEANS at a=0.05 significance. Flumioxazin, pyroxasulfone, and the combination all exhibited symptomology on shoot and injury and mortality was also observed with the shoot + root herbicide exposed treatments, contrary to the hypothesis. The PPO mode of action for flumioxazin was evident in the scarring and destruction of cells with the shoot part of the plant. Very few plants were injured when the roots were exposed to flumioxazin. Pyroxasulfone-treated plants in addition only showed injury symptoms for shoot and shoot+ root exposed treatments. Thus, the flumioxazin and pyroxasulfone combination also supported this pattern of symptomology development and subsequent injury. It is important to distinguish that the injury associated with the flumioxazin was contact, whereas the pyroxasulfone injury was systemically evident. This study did not utilize radiolabeled materials and thus uptake and translocation were not quantified. In conclusion, the location and expression of symptoms from the flumioxazin and pyroxasulfone herbicides was determined to be the shoot of germinating and seedling plants utilizing this novel petri-dish combination. The methodology utilized for this study can be beneficial for training and educational purposes such to demonstrate mode of action as it relates to preemergence herbicide symptomology, and evaluating the potential for crop injury.

CELLULAR UPTAKE AND COMPARTMENTALIZATION OF GLYPHOSATE : A ^{31}P NMR SURVEY OF WEEDY SPECIES. Xia Ge[1], Dana A. d'Avignon*[1], Joseph J. Ackerman[1], Doug Sammons[2], Elizabeth Ostrander[3]; [1]Washington University in St Louis, St Louis, MO, [2]Monsanto, St. Louis, MO, [3]Monsanto, St Louis, MO (131)

Non-target site glyphosate resistance (GR) mechanism(s) play an important role in GR weedy species that have evolved in the past two decades. Understanding GR mechanisms at the cellular level is critical for development of methods to control GR weeds and to sustain associated weed management agricultural practices. Our lab previously reported ^{31}P NMR studies of glyphosate in plants that demonstrated uptake into the cell is an active process and further that rapid vacuole sequestration is the dominant resistance mechanism in both GR horseweed and GR ryegrass species. These observations argue for the presence of membrane pumps that transport glyphosate effectively in a unidirectional manner as long as the plant cell is energetically competent. Expanding these studies to include a wider range of weedy species, we observe that glyphosate uptake into the cell under identical treatment conditions varies widely in a species dependent manner. We also observe vacuole sequestration occurs to variable degree in a number of species, in part explaining variable success with control. Further, some species readily take up glyphosate but are poorly controlled. This observation implies that in these species, delivery to the chloroplast is inhibited, possibly due to a lack of membrane transporters in these species. We conclude that weedy species exhibit a range of response to glyphosate because of: (i) restricted uptake into the plant cell, (ii) vacuole sequestration that serves to shield the chloroplast, and (iii) restricted entry into the chloroplast. In many cases, glyphosate is effective because even with limited membrane transport only a small concentration needs to be delivered to the chloroplast for the plant to be controlled.

THE INFLUENCE OF CATIONS AND FOLIAR FERTIZERS ON 2,4-D AMINE AND DICAMBA EFFICACY. Jared M. Roskamp*, Gurinderbir S. Chahal, William G. Johnson; Purdue University, West Lafayette, IN (132)

With the commercialization of 2,4-D-resistant and dicamba-resistant soybeans, 2,4-D or dicamba may be used post emergence for the control of weeds in soybean. There is potential for these herbicides to be mixed with foliar fertilizers such as manganese and zinc. In the past, studies were conducted to study the influence of cations on the efficacy of weak acid herbicides such as glyphosate. The objectives of this research were to determine if the efficacy of 2,4-D amine and dicamba is influenced by cation solutions, specifically calcium and magnesium, or foliar fertilizers, zinc and manganese; and to study the effect of AMS on 2,4-D and dicamba efficacy in the presence of cation and fertilizer solutions. In separate experiments, each herbicide was mixed with five different water types (deionized water, calcium at 590 mg L^{-1}, magnesium at 630 mg L^{-1}, manganese fertilizer solution, and zinc fertilizer solution) each with or without ammonium sulfate (AMS) and applied to common lambsquarters, horseweed, and redroot pigweed to assess efficacy of the herbicides. Control of horseweed and redroot pigweed was increased when AMS was added to the 2,4-D treatments, irrespective of all water treatments. When comparing the control of 2,4-D on horseweed within each water type, regardless of the presence of AMS, manganese decreased herbicide efficacy. In the absence of AMS, the cations calcium and magnesium decreased 2,4-D efficacy in controlling common lambsquarters. Unlike 2,4-D, dicamba performance on horseweed was not influenced by different water types. Control of redroot pigweed by dicamba was increased when AMS was added in the deionized water, magnesium, and manganese treatments. When dicamba was applied in deionized water, calcium, magnesium, and manganese treatments, control of common lambsquarters by dicamba was greater with AMS than without AMS.

REGIONAL WHOLE PLANT AND MOLECULAR RESPONSE OF KOCHIA TO GLYPHOSATE. Philip Westra*[1], Jan Leach[1], A.S.N. Reddy[1], Dale Shaner[2], Andrew Wiersma[3]; [1]Colorado State University, Fort Collins, CO, [2]USDA, Fort Collins, CO, [3]Colorado State University, Ft. Collins, CO (133)

Glyphosate-resistant *Kochia scoparia* in the central Great Plains of the U.S. threatens hard won advances in reduced tillage based on glyphosate control of weeds. To monitor and assess resistance, *K. scoparia* accessions were collected from fields with putative glyphosate resistance in KS, CO, ND, SD, and Alberta, Canada. Whole plant glyphosate dose response and shikimate assays were used to confirm resistance and assess levels of resistance. PCR, quantitative PCR, sequencing, and immunoblotting were used to determine the mechanism responsible for resistance. Sequence of the *EPSPS* binding site proline confirmed that amino acid substitution at that residue was not responsible for glyphosate resistance. Estimates of *EPSPS* gene copy number revealed increased copy number in all glyphosate-resistant individuals with the increase ranging from 3 to 9 *EPSPS* copies relative to a reference *ALS* gene. Glyphosate-resistant kochia with increased *EPSPS* copy numbers also had consistently reduced shikimate levels in leaf disks treated with 100 µM glyphosate. *EPSPS* copy number was linearly correlated to *EPSPS* transcript abundance, and EPSPS enzyme accumulation was consistently elevated in resistant plants with increased copy number. Based on these findings, we see that the geographic range infested with glyphosate-resistant *K. scoparia* is expanding, and that use of increased glyphosate rates will likely select for higher levels of resistance. These results are consistent with a model attributing increased EPSPS expression as a mechanism for glyphosate resistance in *K. scoparia*. We suggest that lower level increases in EPSPS expression (as compared to *Amaranthus palmeri*) is sufficient for field-level glyphosate resistance. RNA-seq and basic transcriptome assembly of glyphosate-susceptible and -resistant *K. scoparia* is in progress and should lead to a better understanding of factors contributing to resistance.

TOLERANCE OF SELECTED WEED SPECIES TO BROADCAST FLAMING. Strahinja V. Stepanovic*[1], Avishek Datta[2], Neha Rana[3], Stevan Z. Knezevic[3]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Concord, NE (134)

Propane flaming could be an additional tool for controlling winter annual and early emerging summer annuals. Field experiments were conducted in 2012 at two locations at Haskell Ag Lab to determine the tolerance of selected weed species to broadcast flaming.. Weed species included: dandelion (*Taraxacum officinale*), field pennycress (*Thlaspi arvense*), cutleaf evening primrose (*Oenothera lacinata*), henbit (*Laium amplexicaule*), tansy mustard (*Descurainia pinnata*) and common lambsquarter (*Chenopodium album*). Each weed species was treated as separate experiment arranged in a split-plot design, where the main plot effect was growth stage and the split-plot was propane dose. Flaming treatments were applied using an ATV mounted flamer moving at constant speed of 4.8 km/h, and propane pressure was adjusted to deliver dose of 0 (control), 22, 34, 48, 67 and 90 kg/ha. Species response to propane doses were described by log-logistic model based on relative dry matter and visual ratings. Effective dose at 60, 80 and 90% (ED_{60}, ED_{80} and ED_{90}) was calculated from the model. Overall response to broadcast flaming varied among the species and their growth stages. In general, common lambsquarter, tansy mustard and henbit were more susceptible to flaming then cutleaf evening primrose, field pennycress and dandelion. Based on visual ratings, propane dose of 45 to 62 kg/ha effectively controlled (>90% weed control) common lambsquarter at early growth stage (5-leaf), tansy mustard at both growth stages (9-leaf and flowering) and henbit at flowering. However, higher dose (>83 kg/ha) was necessary to provide 90% weed control for later growth stage of lambsquarter (11-leaf) and early growth stage of henbit (9-leaf), suggesting that tolerance to flaming generally increases with increase in plant size, but decreases during flowering. Cutleaf evening primrose, tansy mustard and dandelion exhibited higher level of tolerance to broadcast flaming, requiring 99, 130 and 147 kg/ha of propane to achieve 80% weed control respectively. Results of this study indicated that a single application of broadcast flaming can be an effective tool for controlling tansy mustard, henbit, tansy mustard and lambsquarters. However, repeated flaming is needed to control other winter annuals (field pennycress and primrose) and perennials (dandelion).

CONTROLLING GLYPHOSATE-RESISTANT PALMER AMARANTH USING ATRAZINE TANK MIXES IN CORN. Matthew S. Wiggins*, Kelly A. Barnett, Lawrence E. Steckel; University of Tennessee, Jackson, TN (135)

Glyphosate-resistant (GR) weeds continue to be the most problematic weeds to control in most cropping systems in the Mid-South region of the United States. There are now no less than ten glyphosate-resistant weed species in the Mid-South and no less than six confirmed species glyphosate-resistant species in Tennessee, with Palmer amaranth (*Amaranthus palmeri*) being the most difficult of these to control. This dioecious, broad-leaf species has a robust growth habit, a wide germination window, and can out compete crops for essential resources. Palmer amaranth populations in Tennessee and much of the Mid-South have been documented with multiple resistance to glyphosate and acetolactate synthase (ALS)-inhibiting herbicides. Fortunately, there are some effective herbicides labeled for use in corn. As corn production increases in Tennessee it is imperative for producers to gain knowledge of current control options. Thus a study was conducted in 2012 to determine Palmer amaranth control with Halex GT (glyphosate +mesotrione +s-metolachlor), Capreno (thiencarbazone +tembotrione), RealmQ (rimsulfuron +mesotrione), and Status (diflufenzopyr +dicamba) applied alone and in tank-mix combinations with atrazine. The atrazine was added to determine if it would improve control of Palmer amaranth in corn that was treated before 12” in height. The study was conducted on a farmer’s field in Gibson, County TN in a heavy GR Palmer amaranth infested field. Palmer amaranth control was assessed 7, 14, and 21 days after application. Treatments were applied when Palmer amaranth was six inches in height and corn was at the V7 growth stage. Experimental design was a randomized complete block design with three replications. PROC MIXED was used to analyze data and means were separated using Fisher’s Protected LSD at $P \leq 0.05$. RealmQ (rimsulfuron +mesotrione) and Status (diflunfenzopyr +dicamba) as stand-alone applications added very little to the control of Palmer amaranth with 49 and 57% control 21 days after application, respectively. All tank-mixes including atrazine increased Palmer amaranth control at each assessment. However, Halex GT (glyphosate +mesotrione+ s-metolachlor) provided the highest level of control at each evaluation with 78, 99, and 99% control observed at 7, 14, and 21 days after application, respectively. In summary, effective control of large Palmer amaranth is attainable in corn systems when atrazine is tank-mixed with other labeled corn herbicides. This study would suggest that growers should strive to spray Palmer amaranth in corn prior to it reaching 12” in height so that they can utilize atrazine.

CORN TOLERANCE TO SINGLE AND MULTIPLE FLAMING. Stevan Z. Knezevic*[1], Avishek Datta[2], Strahinja V. Stepanovic[3], Dejan Nedeljkovic[4], Neha Rana[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska - Lincoln, Lincoln, NE, [4]University of Belgrade, Belgrade, Serbia (136)

Weeds are a major yield-limiting factor in both conventional and organic crop production systems. In corn, propane flaming could be used as an alternative tool for weed control. Thus corn tolerance to single and repeated flaming was studied with eight treatments, which included: non-flamed control, and broadcast flaming conducted once at V2 (2-leaf), V4 (4-leaf), and V6 (6-leaf) stage, two times (each at V2 and V4, V2 and V6, and V4 and V6 stages), and three times (at V2, V4, and V6 stages). Weeds were removed by hoeing for the entire growing season. A propane dose of 45 kg ha^{-1} was applied with torches parallel to the crop row and at an operating speed of 4.8 km h^{-1} for all treatments. Crop response was assessed visually at 7 and 28 days after treatment (DAT), with effects on yield components and yield. Maize exhibited excellent tolerance to single and double flaming regardless of the growth stage. However, the triple flaming (at V2, V4, and V6) resulted in more than 30% injury. Maize flamed once and twice produced between 11.1 and 11.6 t ha^{-1} yield, which was statistically similar to the yield obtained from the non-flamed control (11.7 t ha^{-1}). Maize flamed three times (at V2, V4, and V6 stages) yielded 9.9 t ha^{-1}, which was 8.5% lower compared to the non-flamed control yield, and likely would not be acceptable by producers. Results of this study indicate that maize is able to tolerate up to two flaming treatments per season without a loss of yield (sknezevic2@unl.edu).

INVESTIGATIONS OF EARLY-SEASON HERBICIDE AND FUNGICIDE CO-APPLICATIONS IN CORN. Craig B. Solomon*, Jimmy D. Wait, Kevin W. Bradley; University of Missouri, Columbia, MO (137)

Two field trials were conducted in 2011 and 2012 near Columbia, Missouri to determine the effects of herbicide, fungicide, and slow release N fertilizer co-applications on corn injury and yield. All trials were arranged in a RCB design with six replications. In the first experiment, the herbicides rimsulfuron plus mesotrione, thiencarbazone-methyl plus tembotrione, *S*-metolachlor plus glyphosate plus mesotrione, glyphosate plus thiencarbazone-methyl plus tembotrione, glyphosate plus atrazine, mesotrione, glyphosate, and glufosinate were applied alone or in combination with the fungicides prothioconazole plus trifloxystrobin, azoxystrobin plus propiconazole, and pyraclostrobin plus metconazole. In the second experiment, the herbicides glyphosate plus thiencarbazone-methyl plus tembotrione, *S*-metolachlor plus glyphosate plus mesotrione, glyphosate, and glufosinate were also applied alone or in combination with these same three fungicides, and all of these herbicide-fungicide combinations were also applied with or without a slow-release N fertilizer. In both experiments, all treatments were applied at the V5 stage of corn growth. In 2011, treatments containing rimsulfuron plus mesotrione resulted in height reductions of up to 19% of the weed-free, non-treated control at 7 days after treatment (DAT). The same treatments did not result in corn heights less than the non-treated control in 2012. When compared to the weed-free, non-treated control, treatments containing thiencarbazone-methyl plus tembotrione resulted in a 22 and 19% height reduction 7 DAT in 2011 and 2012, respectively. In 2011, when averaged across all fungicide treatments, thiencarbazone-methyl plus tembotrione, thiencarbazone-methyl plus tembotrione plus glyphosate, and rimsulfuron plus mesotrione resulted in lower yields than the weed-free, non-treated control and mesotrione. In 2012, there were no significant yield differences between any of the factors (herbicide, fungicide, slow release N fertilizer) evaluated in either experiment. In both years, when averaged across all herbicide treatments, there were no differences in corn yield between either of the fungicide treatments and the weed-free, non-treated control. Also in both years, when averaged across all herbicide and fungicide co-applications, there were no differences in corn yield between treatments that contained a slow-release N fertilizer compared to those that did not. Disease severity, SPAD meter readings, and stalk strength evaluations were similar for all herbicide and fungicide treatments in comparison to the non-treated control. Overall, results from these experiments indicate that certain early-season herbicide plus fungicide or herbicide plus fungicide plus slow-release N fertilizer combinations can cause substantial reductions in corn height, but that V5 co-applications of herbicides with fungicides or slow-release N fertilizers are not likely to provide increases in corn yield.

THE EFFECT OF VOLUNTEER CORN GROWING IN CORN ON GRAIN QUALITY AND MYCOTOXIN CONTAMINATION. Vanessa L. Garner*, William G. Johnson, Paul T. Marquardt, Kiersten A. Wise; Purdue University, West Lafayette, IN (138)

The widespread adoption of herbicide-resistant (HR) corn and continuous corn cropping systems has resulted in the increase of HR volunteer corn growing in HR hybrid corn. When growing in HR hybrid corn, HR volunteer corn is capable of causing significant yield loss due to competition for valuable resources. In previous studies, it has also been shown that the presence of HR volunteer corn has negative impacts on the efficacy of insect-feeding resistance traits (mainly Bt) by violating mandated insect resistance management strategies. This violation places additional Bt selection pressure on targeted insect pests. Herbicide-resistant volunteer corn may also have an impact on disease development in hybrid corn. It has been hypothesized that the presence of HR volunteer corn in continuous corn systems can cause an increase in grain diseases by providing ideal conditions needed for infection. Of specific concern, is gibberella ear rot (*Fusarium granearium*), which is a disease found in corn that is capable of producing deoxynivalenol (DON) mycotoxins that, if eaten, are harmful to both humans and livestock. Corn grain that contains high levels of mycotoxins has reduced marketability and storage capacity, ultimately resulting in economic loss. Our objective was to evaluate the role of different densities of HR volunteer corn growing in HR hybrid corn on *F. granearium* severity and associated mycotoxins found in grain. A field trial was conducted with HR volunteer corn planted into HR hybrid corn at 0.5, 2, 4, and 8 plants/m^2. Each plot was inoculated with *F. granearium* colonized grain to ensure uniform disease pressure. At maturity, 10 volunteer corn ears and 10 hybrid corn ears were harvested from the center two rows of each plot and visually evaluated for the presence or absence of grain disease. Next, this grain will be analyzed for the presence and quantity of DON. A better understanding of the role that HR volunteer corn plays in the development of disease and the presence of mycotoxins is necessary in determining if supplementary management practices are needed.

TWO-PASS WEED CONTROL IN GLYPHOSATE-RESISTANT CORN - EFFICACY, ENVIRONMENTAL IMPACT, YIELD AND PROFITABILITY.

Peter Sikkema*[1], Robert E. Nurse[2], Chris Gillard[3], Nader Soltani[3]; [1]University of Guelph - Ridgetown Campus, Ridgetown, ON, [2]Agriculture and Agri-Food Canada, Harrow, ON, [3]University of Guelph Ridgetown Campus, Ridgetown, ON (139)

Field trials were conducted over a three-year period (2010 - 2012) at various locations in Southwestern Ontario, Canada to compare various two-pass weed management strategies in glyphosate-tolerant corn for weed control, crop injury, corn yield, environmental impact and profit margin. No visible injury resulted from the herbicide treatments evaluated. One early postemergence application of glyphosate provided good full season control of pigweed species and lady's thumb and fair control of velvetleaf, common ragweed, lambsquarters, barnyard grass and green foxtail. Glyphosate (LPOST) provided excellent control of all the weed species evaluated but corn yield was reduced due to early weed interference. The sequential application of glyphosate (EPOST fb LPOST) provided excellent control of all weed species evaluated with no adverse effect on corn yield. The sequential application of a preemergence herbicide followed by an application of glyphosate LPOST (at 6-8 leaf stage) provided excellent full season control of all the weed species evaluated and corn yield was equal to the weed free control. Among the sequential programs the lowest environmental impact was glyphosate EPOST fb LPOST and saflufenacil/dimethenamid-p, isoxaflutole + atrazine and rimsulfuron + s-metolachlor + dicamba applied PRE fb glyphosate LPOST. Based on this study, the most efficacious and profitable weed management programs in glyphosate-resistant corn are a sequential application of glyphosate or a two-pass program of a preemergence herbicide followed by glyphosate LPOST. The two-pass programs have glyphosate stewardship benefits.

CLETHODIM DOSE RESPONSE CURVES FOR VOLUNTEER CORN CONTROL AND CORN INJURY AFTER AN IMMEDIATE REPLANT.

Randall S. Currie*; Kansas State Univ., Garden City, KS (140)

Few products are available to control glyphosate-resistant volunteer corn prior to planting corn. Although clethodim controls volunteer corn effectively, it may have a soil residual that can injure the subsequent corn crop. Soybean growers are very familiar with clethodim, however, in continuous corn growing regions where glyphosate-resistant volunteer corn is a problem, growers are often unfamiliar with its use and fail to add the proper adjuvant system to produce optimal results. Therefore, it was the objective of this research to produce a dose response curve to measure the impact of soil residual clethodim on corn planted immediately after application and test a clethodim formulation that does not require additional adjuvants. A commercial glyphosate-resistant corn hybrid was planted at 80,000 kernels/ha to simulate volunteer corn in 76 cm rows using no till techniques in wheat stubble. At the four to six leaf-stage, 23 days after planting, clethodim was applied at 0, 0.25, 0.75, 1, 1.5,2 and three times the labeled rate of 0.055 kg/ha. The experimental Arysta clethodim formulation ARY-0411-007 was also applied at 0.75 and 1.5 times the labeled rate. Control plots with and without the hand removals of the volunteer corn were also included. Plots were arranged in a randomized complete block design with four replicates. Within 24 hours of application, corn was replanted as described above and sprinkle irrigated with one inch. Injury to the volunteer corn was well described 18 days after application by an exponential equation: Percent injury = 8.04 e to the 0.32 X power with an R-square value of 0.95. Without additional surfactant, the conventional formulation of Clethodim provided 63% and 84 % control with the 1X and 3X rates, respectively. In contrast, the ARY-0411-007 formulation, without any additional surfactants, produced 94% control of the simulated volunteer corn regardless of the rate used. The interpretation of yield results was further confounded by the impact of additional yield supplied by the simulated volunteer corn. The untreated plots with uninjured volunteer corn, plus the additional corn planted late, produced 7515 kg/ha. In contrast, untreated control plots where the simulated corn was removed, yielded 4817 kg/ha. The simulated volunteer corn was removed from these controls plots at 91 cm, which was too late to allow simple comparisons. Even without surfactant, all rates at or below the labeled rate elevated corn yield incrementally compared to these plots. Above the labeled rates, soil residual clethodim reduced yield incrementally. This polynomial response was described by this equation: corn yield= 23X -3X squared + 56 with an R-square of 0.76 where X is kg/ha clethodim. Even at three times the labeled rate, although injured by soil residual clethodim, corn still yielded 88% of the untreated control.

CARRIER VOLUME INFLUENCE ON THE EFFICACY OF FOUR SOYBEAN HERBICIDES. Cody F. Creech*[1], Lowel Sandell[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (141)

Glyphosate-resistant weeds are becoming more prevalent due to increasing selection pressure from the continual increase in agricultural acres of glyphosate-tolerant crops which has forced many growers to use other herbicides. The objective of this study was to measure the influence of carrier volume on droplet size and weed control using four commonly used soybean postemergence herbicides. The effects of five carrier volumes (47, 70, 94, 140, and 187 L/ha) and four herbicides (glyphosate [RoundUp PowerMax] at 37g ae/ha, glufosinate [Liberty] at 97g ai/ha, lactofen [Cobra] at 36g ai/ha, 2,4-D [Weedone] at 87g ae/ha) on droplet size were evaluated at the wind tunnel facility in North Platte, NE, and weed control ratings were recorded at three field sites located across Nebraska (Lexington, O'Neill, Platte Center). Generally, the performance of systemic herbicides (glyphosate and 2,4-D) on weed control was not influenced by different carrier volumes. An interaction between the effect of carrier volume and the contact herbicides glufosinate and lactofen was observed. Herbicide efficacy in controlling velvetleaf increased from 52 and 37%, respectively, for these two contact herbicides, to 83 and 85% as carrier volume increased from 47 to 187 L/ha.

EFFECT OF APPLICATION CARRIER VOLUME ON HERBICIDE EFFICACY WITH TEN HERBICIDES USING A CONVENTIONAL SPRAYER AND AN ULTRA-LOW VOLUME SPRAYER. J Connor Ferguson*[1], Roch E. Gaussoin[1], John A. Eastin[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kamterter LLC, Waverly, NE, [3]University of Nebraska-Lincoln, North Platte, NE (142)

An Ultra-Low Volume (ULV) sprayer was developed to decrease carrier volume required for pesticide applications in crop production. A field study was conducted at the University of Nebraska-Lincoln West Central Research and Extension Center Dryland Farm near North Platte, NE to determine efficacy of herbicide active ingredients when atomized by a ULV sprayer compared to a conventional sprayer. Ten active ingredients with each sprayer and an untreated check (21 total treatments) were arranged in a randomized complete block design with four replications. The ten herbicides chosen were glyphosate, glufosinate, 2,4-D ester, dicamba, atrazine, saflufenacil, mesotrione, chloransulam-methyl, sodium salt of bentazon, and clethodim. The effect of four drift reducing adjuvants on glyphosate efficacy with the ULV sprayer at two pressures was also evaluated. Four drift reducing adjuvants, a glyphosate check and an untreated check were arranged in a randomized complete block design with four replications. The four adjuvants selected were hydroxyethyl cellulose (HEC), polyethylene oxide (PEO), methylated soybean oil (MSO) and glycerin. Treatments were applied across a 12 row plot planted to six different plant species. Plant species used were non-glyphosate-resistant (*Zea mays* L.) non-glyphosate-resistant soybeans (*Glycine max* (L.) Merr.), amaranth (*Amaranthus hypochondriacus* L.), quinoa (*Chenopodium quinoa* Willd.), velvetleaf (*Abutilon theophrasti* Medik.), and green foxtail (*Setaria viridis* (L.) Beauv.). Treatments in both studies were analyzed for their relative particle size on a laser diffraction instrument to compare droplet size spectra and determine if differences in droplet sizes exist between the two sprayers. Five plants of each species per plot were harvested four weeks after application, dried for 48 hours at 63°C and dry weights were recorded. The active ingredient study yielded no difference in efficacy between sprayer types across all six species in 2011 but was different in corn in 2012. Simple effect differences of treatment by sprayer type were observed in both years. The adjuvant study had no difference in glyphosate efficacy across the four adjuvants or the glyphosate check over the six species in 2011 and corn and soybean in 2012. Additionally, operating pressure did not affect efficacy across all treatments. The results indicate that the ULV sprayer is potentially an effective method for delivering herbicides.

REAL WORLD EXPOSURE AND BIOMONITORING ARE NOT PART OF THE ALARMIST AGENDA. Larry E. Hammond*; 2,4-D Task Force, Carmel, IN (143)

Toxicological data has been mis-represented to express alarm and multiple health effects. Detection does not mean health concerns. To a large segment of the public and exploited by environmentalist, exposure to pesticides means harm. EPA guideline testing requires determining toxicological limits of a pesticide called hazard, thus, those values are the focus of the alarmist. The NOAEL nor the 100X lower RfD nor real world biomonitoring exposure is considered. Selected old publications and adverse findings are highlighted. In contrast there is a huge difference in the recent 2,4-D one-gen reproduction study; the male systemic toxicity NOAEL is ~13,000-fold higher than 2,4-D exposures reported in human biomonitoring studies. Also, there is huge difference between the Agency's 2,4-D reference dose and the CDC NHANES biomonitoring. After rigorous analysis of the relevant scientific data, expert panels and government agencies all reach the same conclusion: 2,4-D is acceptable for use according to label directions.

EVALUATION OF TOLERANCE AND ROOT QUALITY ON AZALEA AND HYDRANGEA TREATED WITH DIMETHENAMID-P AND PENDIMETHALIN ALONE AND IN MIXTURES.

Jose J. Vargas*[1], James Brosnan[2]; [1]The University of Tennessee, Knoxville, TN, [2]University of Tennessee, Knoxville, TN (144)

Research was conducted during 2012 at the University of Tennessee (Knoxville, TN) evaluating the effects of various preemergence herbicides on azaleas (Rhododendron sp. var. "Amy Cotta") and hydrangeas (Hydrangea sp. var. "Limelight"). Separate studies for each species were arranged in randomized complete block designs with three replications. Treatments in each study included: dimethenamid-P (1680 and 3360 g ai/ha), pendimethalin (4500 g ai/ha), dimethenamid-P + pendimethalin (1840 + 1120, 1680 + 2240, 3360 + 4480 g ai/ha, respectively), BAS 659 EUH EXP (1960, 3920 and 7850 g ai/ha), and trifluralin + isoxaben (4500 + 1120 g ai/ha). Both a weed infested and weed-free non-treated check were included for comparison. Granular treatments were applied by hand while liquids were applied using a CO2 powered sprayer calibrated to deliver 215 L/ha at 310 kPa. Herbicide applications were made to liners transplanted into 3.8 L containers filled with pine bark growing media. Plants were allowed to acclimate in a greenhouse for 5 days prior to herbicide treatment; during this time growing media in the containers was allowed to settle through two watering cycles. All treatments were applied sequentially on a six week interval. Phytotoxicity, discoloration, twisting, and necrosis were visually assessed on foliage at 7, 14, 28, 42, 56 and 112 days after each herbicide application. In addition, root quality was assessed 42 and 84 days after initial treatment (DAIT) using a 0 (i.e, lowest) to 5 (i.e., highest) scale relative to the non-treated checks. Multiple plants received each treatment to facilitate destructive root sampling. On hydrangeas, the mixture of pendimethalin + dimethenamid-P (3360 + 4480 g ai/ha) and BAS 659 EUH EXP (7850 g ai/ha) resulted in 17 to 23% phytotoxicity 42 DAIT; both rates of dimethenamid-P yielded a similar response as well. Pendimethalin + dimethenamid-P (1680 + 2240 and 3360 + 4480 g ai/ha) and BAS 659 EUH EXP (7850 g ai/ha) resulted in slight reductions in root quality compared to the non-treated checks. No significant differences in root quality were detected among treatments by 84 DAIT. By 84 DAIT, all treatments except the mixture of pendimethalin + dimethenamid-P (1840 + 1120, 1680 + 2240 g ai/ha) and BAS 659 EUH EXP (1960 g ai/ha) resulted in phytotoxicity (18 to 38%) compared to the non-treated checks. Few significant differences in phytotoxicity were detected between pendimethalin + dimethenamid-P and BAS 659 EUH EXP regardless of rate. On azaleas, no significant differences in phytotoxicity or root quality were detected among applied treatments 42 DAIT. By 84 DAIT, BAS 659 EUH EXP (3920 g ai/ha), pendimethalin + dimethenamid-P (1680 + 2240 g ai/ha), and dimethenamid-P (1680 g ai/ha) resulted in phytotoxicity greater than the non-treated checks (21 to 48%). However, no significant differences in root quality were detected at this assessment interval. BAS 659 EUH EXP (7850 g ai/ha) resulted in lower phytotoxicity than mixtures of pendimethalin + dimethenamid-P (3360 + 4480 g ai/ha) 56 DAIT until the end of the trial.

EFFECTS OF FLAMING AND CULTIVATION ON WEED CONTROL AND YIELD IN ORGANIC CORN AS INFLUENCED BY MANURE APPLICATION.

Strahinja V. Stepanovic*[1], Avishek Datta[2], Neha Rana[3], Brian D. Neilson[4], Chris Bruening[1], George Gogos[1], Stevan Z. Knezevic[3]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska-Lincoln, Lincoln, NE (145)

Weed management is a major constraint in organic crop production. Propane flaming combined with mechanical cultivation in a single operation could be an additional tool for weed control in organic corn. Field studies were conducted in a certified organic field at the Haskell Agricultural Laboratory in 2010, 2011, and 2012. The objective was to determine the level of weed control and response of organic corn grown with and without manure to flaming and cultivation. The treatments included: weed-free control, weedy season-long, and combinations of banded flaming (intra-row), broadcast flaming, and mechanical cultivation (inter-row), applied at the V3 and/or V6 growth stages. Treatments were applied utilizing flaming equipment developed at UNL. Propane doses were 20 and 45 kg/ha for the banded and broadcast flaming, respectively. Crop response and weed control was evaluated visually at 1, 7, 14, and 28 days after treatment (DAT). All evaluated parameters (yield, weed control, crop injury) indicated that there was no interaction between manure application and treatment; however, there was an increase in corn yield with addition of manure. Overall, all flaming treatments showed less than 10% injury at 28 DAT suggesting good corn tolerance to flaming. Best results were observed in plots which included banded flaming followed by cultivation conducted twice (at V3 and V6 stages), which provided greater than 90% weed control and only 5% yield reduction. This is suggesting that flaming and cultivation have a potential for use in organic corn production.

GRADUATE EDUCATION IN WEED SCIENCE: IN WITH THE NEW AND OUT WITH THE OLD? Philip Westra*; Colorado State University, Fort Collins, CO (147)

There is increasing demand on agriculture to meet the increasing world demand for food, fuel, and fiber. At this critical time for agriculture, many current agricultural scientists are reaching retirement age. Consequently, there looms an alarming shortage of highly qualified graduate students to meet the personnel demands of industry, universities, and government. This includes students trained in both applied and basic sciences to allow the rapid integration of cutting-edge science into the field. Current funding mechanisms for graduate students rely on competitive grants. This limits the number of students that can be trained, particularly in the applied fields where funding has been limited. A new model for graduate student training in agriculture must be developed to fulfill the demand for applied agricultural scientists. This model could include federal and state base funding for graduate student education as well as new models for industry support for graduate student training. Foundation funding may also be a potential source for these funds. In addition, student knowledge and experience with new technologies such as molecular biology and bioinformatics will increasingly become important for long-term productive careers whether one works in more applied areas or in more basic research areas. A primary objective is to increase funding for graduate student training in agricultural sciences. The key issue is how current funding mechanisms have resulted in a large reduction in the training of graduate students in applied agricultural fields. Consequently, candidate pools for positions in Extension or agronomic advisers in industry are small and many candidates are not adequately trained. Our weed science societies need to:

1. Raise collective awareness of the need to recruit high quality graduate students into agricultural sciences graduate programs – novel student recruitment efforts will be central to this plan;
2. Evaluate new and emerging curriculum needs to adequately train these students;
3. Forge new and creative relationships among universities, private companies, and agencies to support such a collective effort;
4. Create a “clearing house” where students could obtain internships or work experience as part of their education

WANT TO BE A WEED SCIENTIST WITH UNIVERSITY OR INDUSTRY? Amit Jhala*[1], Vince M. Davis[2], Joe Armstrong[3], Lillian C. Magidow[4]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]Dow AgroSciences, Davenport, IA, [4]Winfield Solutions, St. Paul, MN (151)

The mission statement of the North Central Weed Science Society (NCWSS) is to deliver research, education, and training to persons responsible for weeds and their management in land use systems. Graduate students are an important component of the future success of the society. The professional development committee created this symposium to enable graduate students to investigate career paths in an academic or industry setting, two important job segments for new weed scientists. There are also other job segments for weed science graduate students, such as the United States Department of Agriculture, Agricultural Research Service (USDA-ARS), state governments, and private practices that could be discussed in future NCWSS meetings. For this symposium, two early-career weed scientists from Universities and two from industry will discuss factors that allowed them to secure their first career positions. They will discuss topics for current graduate students to consider as they develop their early careers. Graduate students will be encouraged to get involved in the discussion and ask questions (e.g. What are the first things you should learn as a young weed science professional? How do you balance family and work? Is it possible to move across job segments in weed science?) This profession is small and technical skills are central to your ability, but networking, accountability, and credibility are vital components of early success. Continual professional and personal development is also necessary to ensure flexibility and adaptability for opportunities, challenges, and changes that will arise during the course of your career. We believe that open discussion during this symposium will provide many other important points for graduate students to consider reaching their first career positions so they can plan and improve their skills and résumés now.

WEED CONTROL IN DICAMBA TOLERANT SOYBEAN. Pratap Devkota*[1], William G. Johnson[1], John B. Willis[2]; [1]Purdue University, West Lafayette, IN, [2]Monsanto, Hanson, KY (153)

A field experiment was conducted in summer 2012 at Southeast Purdue Agricultural Center in IN. The primary objective of the experiment was to compare the effectiveness of dicamba formulations with 2,4-D and glyphosate for horseweed control. Treatments consisted of two different rates of 2,4-D Amine (840 and 1120 g ae/ha); Roundup WeatherMAX (840 and 1120 g ae/ha); MON 100111, an experimental dicamba straight goods product (420 and 560 g ae/ha); and MON 76754, an experimental glyphosate/dicamba premix formulation (1260 and 1680 g ae/ha). In addition, lower and higher rates of 2,4-D Amine were mixed with Durango DMA at 840 and 1120 g ae/ha, respectively; while, lower and higher rates of MON 100111 and Roundup WeatherMAX were mixed and evaluated. Plots were rated at 14 and 21 days after treatment (DAT) for horseweed control. At 14 DAT, 2,4-D Amine; MON 100111; MON 76764; 2,4-D Amine plus Durango DMA; and MON 100111 plus Roundup WeatherMAX did not differ significantly for horseweed control. However, 2,4-D Amine plus Durango DMA; MON 100111 plus Roundup WeatherMAX mixed at higher rates controlled horseweed 96% which was significantly greater than the control from Roundup WeatherMAX alone (<43%). Likewise, MON 76754 was more effective for horseweed control than Roundup WeatherMAX alone at 840 g ae/ha. At 21 DAT, MON 100111 plus Roundup WeatherMAX had greater activity on horseweed than 2,4-D Amine or Roundup WeatherMAX applied alone. The combination of MON 100111 and Roundup WeatherMAX provided 100% control of horseweed in fallow application. Likewise, MON 76754 at 1680 g ae/ha provided higher percentage control (94%) of horseweed than control with Roundup WeatherMAX alone (<75%).

WEED MANAGEMENT WITH ROUNDUP READY®2 XTEND SOYBEAN IN IOWA. Dean M. Grossnickle*[1], Micheal D. Owen[2], Damian D. Franzenburg[3], James F. Lux[3], Justin M. Pollard[4]; [1]Iowa State University, Gilbert, IA, [2]ISU, Ames, IA, [3]Iowa State University, Ames, IA, [4]The Monsanto Company, St. Louis, MO (154)

Field experiments were conducted during the spring 2011 and 2012 near Ankeny, Iowa to evaluate glyphosate-resistant common waterhemp control with the Roundup Ready® 2 Xtend soybean and selected herbicides. Evaluated application timings included preemergence (PRE), postemergence (POST), and PRE followed by (fb) POST. PRE treatments consisted of flumioxazin and chlorimuron ethyl at 63 + 21.6 g ai ha^{-1} while POST treatments consisted of glyphosate at 862 g ae ha $^{-}$1 alone and with one or more of the following active ingredients; dicamba at 560 g ae ha^{-1}, fomesafen at 395.5 g ai ha^{-1}, lactofen at 201.65 g ai ha^{-1}, and acetochlor at 1.26 kg ai ha^{-1} applied when the common waterhemp was 15-30 cm tall. In 2012 MON 76754, an experimental premix formulation of dicamba and glyphosate was applied at 1.68 kg ae ha^{-1}. Common waterhemp was evaluated 14, 21, and 86 days after treatment (DAT). All PRE fb POST herbicide treatments with more than two active ingredients in the POST application provided greater than 93% control of glyphosate-resistant (GR) common waterhemp when evaluated 14 DAT and 86 DAT. POST applications of glyphosate tank mixed with dicamba controlled greater than 83% of GR common waterhemp while POST glyphosate alone controlled 13% to 70% of GR common waterhemp 14 and 86 DAT.

WEED MANAGEMENT RECOMMENDATIONS FOR ROUNDUP READY® 2 XTEND SOYBEANS. Simone Seifert-Higgins*[1], John B. Willis[2]; [1]Monsanto Company, St. Louis, MO, [2]Monsanto, Hanson, KY (155)

Two field protocols were conducted in 2012 to evaluate herbicide options for the control of glyphosate-resistant (GR) and hard-to-control weeds in Roundup Ready® 2 Xtend soybean. Twenty-two research locations were focused on weed management benefits of Roundup Ready® 2 Xtend soybean under conventional tillage practices across the Midwest. The conventional tillage protocol included initial herbicide applications of pre-emergence (PRE) and/or post-emergence (POST) when plants measured 8 to 10-cm in height. Additional POST treatments were made when additional emerged weeds measured 8 to 10-cm in height. The PRE treatments evaluated included 0.071 kg ha^{-1} flumioxazin plus 0.022 kg ha^{-1} chlorimuron. All POST applications included: 1.15 kg ha^{-1} glyphosate applied alone or in combination with 0.21 kg ha^{-1} lactofen; 0.56 kg ha^{-1} dicamba plus 1.15 kg ha^{-1} glyphosate or 0.56 kg ha^{-1} dicamba plus 1.15 kg ha^{-1} glyphosate plus 1.27 kg ha^{-1} acetochlor. Nineteen locations evaluated Roundup Ready® 2 Xtend soybean in a minimum tillage system. All pre-plant treatments included 1.15 kg ha^{-1} glyphosate alone or combined with: 0.56 kg ha^{-1} 2,4-D; 0.56 kg ha^{-1} dicamba; 0.071 kg ha^{-1} flumioxazin plus 0.022 kg ha^{-1} chlorimuron plus 0.56 kg ha^{-1} 2,4-D; 0.071 kg ha^{-1} flumioxazin plus 0.022 kg ha^{-1} chlorimuron plus 0.56 kg ha^{-1} dicamba. POST applications occurred when weeds measured 8 to 10-cm in height. All POST applications contained 1.15 kg ha^{-1} glyphosate applied alone or in combination with one of the following: 0.56 kg ha^{-1} dicamba or 0.21 kg ha^{-1} lactofen. Dicamba was evaluated as a premix formulation consisting of dicamba plus glyphosate in both the conventional and minimum till research locations. Visual weed control was determined approximately 21 days after application (DAA) of the final POST applications. Overall weed control averaged across all species ranged between 73 and 94% control under conventional tillage conditions. All dicamba-containing treatments averaged 89 to 94% control across all weed species. Under minimum tillage overall weed control ranged between 92 to 96% when a residual herbicide was included in the burndown treatment. Incorporating dicamba into the burndown treatment significantly improved overall weed control compared to a glyphosate only or glyphosate plus 2,4-D burndown treatment. This research confirms findings that incorporating dicamba into current weed management recommendations as burndown, PRE or POST treatment can provide an additional tool for effective, season-long weed management.

WEED MANAGEMENT IN DICAMBA TOLERANT CROPS WITH ENGENIA™. Troy D. Klingaman*[1], John Frihauf[2], Steven J. Bowe[3], Terrance M. Cannan[2], Luke L. Bozeman[3]; [1]BASF Corporation, Seymour, IL, [2]BASF Corporation, Raleigh, NC, [3]BASF Corporation, Research Triangle Park, NC (156)

Dicamba has been a highly effective weed management tool for nearly 50 years. Engenia™ herbicide is a new experimental formulation (pending regulatory approval, commercialization anticipated in 2014) based on the BAPMA (N, N-Bis-(aminopropyl) methylamine) form of dicamba. Engenia herbicide reduces the volatilization potential of dicamba beyond the improvement achieved with Clarity® herbicide over Banvel® herbicide. Engenia herbicide has been shown in research trials to effectively control many problematic weed species such as ragweed (*Ambrosia* spp.), common cocklebur (*Xanthium strumarium*), common lambsquarters (*Chenopodium album*), morningglory (*Ipomoea* spp.), pigweed (*Amaranthus* spp.), and horseweed (*Conyza canadensis*). The auxin agonist mechanism of action of Engenia herbicide will provide growers the opportunity to effectively control broadleaf weeds 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 will provide burndown with critical broad spectrum early season residual control. Postemergence use of dicamba with glyphosate and other effective herbicides following a PRE or preplant residual herbicide often provides the most consistent and effective control. Optimum postemergence control has been shown when Engenia herbicide is applied to small weeds no larger than four inches. Integration of weed management strategies that combine herbicide, cultural and mechanical control techniques such as alternative herbicide mechanisms of action, crop rotation, and sanitation are critical to effectively manage herbicide resistant weeds and protect the utility of dicamba-tolerant cropping systems.

INFLUENCE OF NOZZLE SELECTION ON DRIFT POTENTIAL AND EFFICACY OF ENGENIA™. Leo D. Charvat*[1], Walter E. Thomas[2], John Frihauf[3], Steven J. Bowe[2], Greg R. Kruger[4]; [1]BASF Corporation, Lincoln, NE, [2]BASF Corporation, Research Triangle Park, NC, [3]BASF Corporation, Raleigh, NC, [4]University of Nebraska-Lincoln, North Platte, NE (157)

New weed control options are needed to help manage a growing weed resistance problem. Dicamba-tolerant soybean and cotton will enable the use of dicamba to manage these problematic broadleaf weeds with an additional herbicide mechanism-of-action. These dicamba tolerant cropping systems will allow for application of dicamba as a preplant burndown without a planting interval and postemergence over the top of the crop. Engenia herbicide, currently not registered by the US EPA, will be an advanced formulation based on the proprietary BAPMA (N, N-Bis-(aminopropyl) methylamine) dicamba that reduces potential volatilization more than Clarity® herbicide, which in itself was an improvement over other formulations. In addition to addressing volatilization through formulation innovation, a comprehensive stewardship strategy will be implemented to focus on weed management and effective control, weed resistance management, and maximizing on-target application. In order to maximize on-target deposition, many parameters related to equipment setup and environmental conditions should be considered. Nozzle selection offers the opportunity to dramatically reduce the potential for spray drift. Research shows that venturi-type nozzle technology can greatly reduce drift potential compared to standard hydraulic flat-fan nozzles. Other application parameters that should be considered include wind speed and direction, travel speed, boom height, application volume, use of a deposition aids, and proximity to sensitive crops. BASF has initiated the 'On Target Spray Academy' training series to educate applicators on best application practices. Drift potential also is strongly influenced by environmental conditions such as wind speed and temperature inversions creating a need to educate applicators on making applications under the most optimal conditions for limiting off-target movement. The combination of Engenia herbicide and dicamba-tolerant crops plus a stewardship strategy will provide growers with an effective system to control herbicide-resistant and difficult to control broadleaf weeds. Pending regulatory approvals, commercialization of Engenia herbicide is anticipated to coincide with the launch of dicamba tolerant soybean in 2014.

ENLIST™ SOYBEAN TOLERANCE TO APPLICATIONS FROM EMERGENCE TO THE R2 GROWTH STAGE.

Eric F. Scherder*[1], David C. Ruen[2], Jeff M. Ellis[3], Ralph B. Lassiter[4], Hunter Perry[5]; [1]Dow AgroSciences, Huxley, IA, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Smithville, MO, [4]Dow AgroSciences, Little Rock, AR, [5]Dow AgroSciences, Greenville, MS (158)

Previous research with Enlist soybean across the Mid-South and Midwest, in 2008 through 2011, demonstrated robust tolerance to 2,4-D when applied preemergence or postemergence. In 2012, trials were initiated to evaluate injury to Enlist soybean stacked with glyphosate tolerance following applications of Enlist Duo™ herbicide, a proprietary blend of 2,4-D choline and glyphosate, applied at 1640, 2185 and 4370 g ae/ha. Single herbicide treatments were applied at VE, V2, V6 and R2 growth stages. Sequential herbicide treatments were also made at V2 followed by V6 and V6 followed by R2 soybean growth stages. Enlist soybean stacked with glyphosate tolerance demonstrated robust tolerance to Enlist Duo across all application timings and rates. Overall injury with 2815 g ae/ha was less than 5% at any single application timing or in a sequential program 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. Enlist soybean stacked with glyphosate tolerance had minimal crop response to Enlist Duo at all applications timings.

®™Trademark ofDow AgroSciences LLC. Components of the Enlist Weed Control System have not yet received regulatory approvals; approvals are pending. The information presented here is not an offer for sale. Enlist Duo herbicide is not yet registered for sale or use as a component of the Enlist Weed Control System. Always read and follow label directions. ©2012 Dow AgroSciences LLC.

WEED CONTROL OPTIONS IN ENLIST™ SOYBEAN.

Jeff M. Ellis*[1], Ralph B. Lassiter[2], Bradley W. Hopkins[3], Fikru F. Haile[4], Deane K. Zahn[5]; [1]Dow AgroSciences, Smithville, MO, [2]Dow AgroSciences, Little Rock, AR, [3]Dow AgroSciences, Westerville, OH, [4]Dow AgroSciences, Indianapolis, IN, [5]Dow AgroSciences, Lincoln, NE (159)

The Enlist™ Weed Control System currently in development at Dow AgroSciences, inlcudes Enlist™ herbicide tolerant traits and an associated Enlist™ herbicide (2,4-D choline + glyphosate DMA). Components of the Enlist™ system are under review for regulatory approval. Weed control programs that utilize soil foundation treatments followed by postemergence applications of mixed modes of action provide consistent, highly effective control and help prevent the onset of herbicide-resistant weeds. A total of 30 studies were conducted in 2011 and 2012 within the U.S. to evaluate the weed control delivered by a systems approach composed of preemergence followed by postemergence herbicide applications. Preemergence treatments consisted of cloransulam + sulfentrazone, flumioxazin, flumioxazin + chlorimuron ethyl or *S*-metolachlor + fomesafen. Postemergence treatments of Enlist Duo™ herbicide (2,4-D choline + glyphosate DMA) were applied at 1092, 1640, and 2185 g ae/ha at approximately 30 days after planting. Separate experiments were conducted in the U.S. at 5 locations in 2011, and 20 locations in 2012 to evaluate a total postemergence weed control program consisting of Enlist Duo alone or in combination with micro-encapsulated acetochlor, fomesafen or *S*-metolachlor + fomesafen. Treatments included applications at the V3 soybean growth stage or V3 growth stage followed by a second application 17 to 21 days later. Enlist Duo™ provided greater than 95% control of several key broadleaf weed species (AMAPA, AMBEL, AMBTR, SIDSP, CHEAL, and ABUTH) that are difficult to control or resistant to glyphosate.

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WEED MANAGEMENT PROGRAMS UTILIZING MESOTRIONE IN HERBICIDE TOLERANT SOYBEANS.

Ryan D. Lins*[1], Dain Bruns[2], Thomas H. Beckett[3], Gordon D. Vail[3]; [1]Syngenta, Byron, MN, [2]Syngenta, Marysville, OH, [3]Syngenta, Greensboro, NC (161)

Field trials were conducted in 2011 and 2012 to assess potential weed control programs for mesotrione use in HPPD-tolerant soybeans. Several programs provided near complete control of important weed species, including targeted glyphosate resistant populations. The most successful programs included preemergence residual weed control with multiple, overlapping modes of action. The use of these chemically diverse and novel programs offers effective, safe and sustainable weed management options for soybean growers.

UNIVERSITY EVALUATION OF ISOXAFLUTOLE WEED MANAGEMENT PROGRAMS IN HPPD TOLERANT SOYBEAN SYSTEM.

Michael L. Weber*[1], Jayla Allen[2]; [1]Bayer CropScience, Indianola, IA, [2]Bayer CropScience, Research Triangle Park, NC (162)

M.S. Technologies and Bayer CropScience are developing a new soybean event that is tolerant to both glyphosate and p-hydroxyphenyl pyruvate dioxygenase (HPPD) inhibitor herbicides. Tolerance to glyphosate is equal to commercially available soybean lines. There is differential tolerance to HPPD inhibiting herbicides in this new event. This event is tolerant to preemergence applications of isoxaflutole and mesotrione. There are varying levels of tolerance to postemergence applied HPPD inhibitors. This event exhibits the best postemergence tolerance to isoxaflutole. There is reduced tolerance to mesotrione, topramezone and tembotrione in this soybean event.

GLYPHOSATE-RESISTANT GIANT RAGWEED CONTROL WITH FUTURE WEED CONTROL TECHNOLOGIES.

Kelly A. Barnett*[1], Thomas C. Mueller[2], Lawrence E. Steckel[1]; [1]University of Tennessee, Jackson, TN, [2]University of Tennessee, Knoxville, TN (163)

Glyphosate-resistant (GR) giant ragweed is a challenge for growers, but the availability of glufosinate-tolerant crops and the near release of 2,4-D- and dicamba-tolerant crops may provide growers with new postemergence control options to control GR giant ragweed. Few control options exist for GR giant ragweed, but fomesafen is one of the more effective postemergence options currently available in soybean. The ability to apply glufosinate is increasing each year with the use of glufosinate-tolerant crops in Tennessee. The nearing release of 2,4-D- and dicamba-tolerant crops may provide growers with additional tools to control GR weeds. Both 2,4-D and dicamba are herbicides recommended for giant ragweed control in corn and therefore, may be effective options with these new technologies. Therefore, a study was conducted in 2011 and 2012 to determine GR giant ragweed control with 2,4-D, dicamba, fomesafen, and glufosinate applied alone and in tank-mix combinations. Giant ragweed control was assessed 10, 20, and 30 days after applications and giant ragweed counts and fresh biomass were also measured 30 days after application. Experimental design was a randomized complete block design with 3 replications. In addition to an ANOVA, single degree of freedom contrast statements were constructed to compare treatments of herbicides applied alone versus herbicide tank-mixes as well as 2,4-D treatments with dicamba treatments. Glyphosate provided less than 30% control at each visual evaluation. 2,4-D or dicamba tank-mixed with glufosinate were the treatments that resulted in the highest level of giant ragweed control at all evaluation timings. However, 30 days after application, all herbicide treatments resulted in > 88% control, with the exception of 2,4-D at 0.56 kg ae ha^{-1}, glyphosate, and glufosinate alone. At earlier evaluations, glufosinate appeared to provide effective giant ragweed control, but this decreased from initial evaluations. Previous research would indicate that multiple applications of glufosinate will be necessary to control larger GR giant ragweed. Giant ragweed counts and biomass coincided with visual evaluations. 2,4-D at 0.56 kg ae ha^{-1}, glyphosate alone, and glufosinate alone had the highest number of giant ragweed plants and biomass and glufosinate plus dicamba at 0.56 kg ae ha^{-1} also had the highest number of plants, but not biomass. Contrast statements comparing 2,4-D treatments with dicamba treatments, indicated that there were no differences between these treatments for visual control evaluations, counts, or biomass. Contrast statements comparing herbicides applied alone with tank-mix treatments indicated that tank-mix treatments provided a higher level of visual control with 86, 91, and 93% control at 10, 20, and 30 days after application while herbicides applied alone only provided 51, 58, and 61% control, respectively. Tank-mix treatments also had fewer giant ragweed plants and reduced biomass when c ompared to herbicides applied alone. Tank-mixing 2,4-D and dicamba with glufosinate or fomsafen (in soybean) will be important for growers to effectively control GR giant ragweed.

AN UNCONVENTIONAL APPROACH TO HERBICIDE RESISTANCE MANAGEMENT. John E. Kaufmann*; Kaufmann AgKnowledge, Okemos, MI (164)

The conventional method of herbicide resistance management is primarily based on 1) grouping the herbicides according to mechanism of action, 2) placing a group ID symbol on the label, and 3) communicating to the end user to avoid consecutive use of any herbicide having the same ID symbol. Additional resistance management statements include the need for scouting, record keeping, good sanitary practices, crop rotation, prompt reporting of suspected non-performance of herbicides and a timely follow-up to determine reasons for non-performance. However, grouping the herbicides according mechanism of action and using that information as the primary consideration for weed resistance management seems to preclude other characteristics of individual herbicides (often within a group) that can also influence the development of resistant weeds. This paper will examine the role of other herbicide characteristics such as selectivity and length of residual action, as well as the role of weed biology in herbicide resistance management.

HERBICIDE RESISTANCES IN COMMON WATERHEMP. Micheal D. Owen*; ISU, Ames, IA (165)

Concerns about herbicide resistance, particularly in common waterhemp (*Amaranthus tuberculatus*) have been discussed since the 1980's. At that time, ALS inhibitor herbicides (Group 2) were applied to a majority of the corn and soybean acres across the Midwest. In the 1990's, concerns focused on the inevitability of evolved resistance to glyphosate (Group 9) and the first glyphosate-resistant common waterhemp populations were identified coincidentally in Badger and Everly, Iowa in 1997. However, glyphosate resistance in common waterhemp was generally scattered in fields and had not become a major concern to agriculture. In 2008, approximately 220 fields with common waterhemp populations were sampled arbitrarily in the fall and evaluated for resistance to glyphosate. In a greenhouse screen where the populations challenged with 3.09 lbs a.e. per acre, 16% of the populations demonstrated a resistant phenotype. Despite this, and the increasing discussions about glyphosate resistance, little was done by agriculture to mitigate the problem, whether proactively or otherwise. However, it was increasingly obvious that herbicide resistance in common waterhemp was increasing at an increasing rate. Resistance to PSII inhibitors (Group 5) and PPO inhibitors (Group 14) was becoming widely reported in common waterhemp and it was no great surprise when resistance to auxinic herbicides (Group 4) and HPPD inhibitors (Group 27). In 2011, the Iowa Soybean Association requested that Iowa State University submit a proposal to evaluate herbicide resistance in Iowa with an emphasis on glyphosate. More than 200 common waterhemp populations were collected in fall 2011 and similar collections were made in fall 2012. Together, more than 600 common waterhemp populations in Iowa were sampled. Evaluations of the 2011 populations are currently underway and approximately 60% of populations have been evaluated for resistance to five sites of herbicide action; the herbicide sites of action included in the evaluations are representatives of the ALS inhibitor herbicides (Group 2), PSII inhibitors (Group 5), EPSPS (Group 9), PPO inhibitor herbicides (Group 14) and HPPD inhibitor herbicides (Group 27). Representatives of each of these herbicide sites of action were applied postemergence to common waterhemp populations in the greenhouse at the typical field use rates (1X) and at four times this rate. Imazethapyr was applied at 0.0625 and 0.25 lb ai A^{-1}, atrazine was applied at 1 and 4 lbs ai A^{-1}, glyphosate at 0.8 and 3.09 lbs ae A^{-1}, lactofen at 0.19 and 0.75 lb ai A^{-1}, and mesotrione at 0.094 and 0.375 lb ai A^{-1} when common waterhemp were 2 to 4 inches tall with appropriate additives included. Resistance was assessed on the relative control of the populations when compared to a known susceptible common waterhemp populations. Evaluations were on a 0 to 100% scale where 0 indicated no herbicide activity and 100% indicated all plants were sensitive. Values below 90% control when compared to the susceptible population were deemed to indicate that resistance had evolved in the specific population. Most of the populations that were designated as resistant still contain sensitive plants. More than 93% of the populations evaluated thus far demonstrate a resistant phenotype when challenged with a field rate of imazethapyr. When the rate increased to 4X, 86% of the populations were still evaluated as resistant. The rate of the PSII herbicide did not change the relative percentages of the resistant populations as 58% and 57% of the common waterhemp populations had a resistant phenotype to 1X and 4X atrazine, respectively. When the populations evaluated thus far were treated with a field rate of glyphosate, 53% of the common waterhemp populations were assessed to be resistant while the number declined to 21% when the glyphosate rate was quadrupled. There was no effect of lactofen rate on the percentage of resistance in common waterhemp; 6% were resistant to the field rate while 5% were resistant to the 4X rate. There was a significant effect of rate for mesotrione as 27% of the common waterhemp populations evaluated thus far were assessed to be resistant to the field rate of mesotrione while the percentage declined to 4% at the 4X rate. One important aspect of the research sponsored by the Iowa Soybean Association, compared to the assessment of glyphosate resistance in Iowa common waterhemp populations that was conducted in 2008 was the ability to assess multiple herbicide resistances in the populations. Given that common waterhemp has demonstrated the ability to evolve resistance to six different sites of herbicide action (the five included in this study and the auxinic herbicides dicamba and 2, 4-D), it is critically important to know exactly which herbicides are still effective when planning a common waterhemp management program. When populations have evolved resistance to more than one site of herbicide action, the herbicide options available quickly decline. A majority of the common waterhemp populations from the 2011 collections evaluated thus far demonstrated multiple resistances. The most prevalent multiple resistant phenotype was populations of Iowa common waterhemp resistant to ALS inhibitor herbicides, PSII herbicides and glyphosate (29%). Common waterhemp populations that had evolved resistance to two sites of herbicide action accounted for 32% of the populations evaluated thus far. Resistance to three herbicide sites of action included 37% of the populations (the dominate phenotype was resistance to ALS/PSII/GLY) while resistance to four herbicide sites of action included 14% of the populations. Three populations (2%) were resistant to all herbicide sites of action. Based on the preliminary data, it is clear that managing herbicide resistant populations of common waterhemp will become increasingly challenging in the near future. Of great concern is the resistance to the HPPD inhibitor herbicides. It is important to recognize that the data is preliminary but if the trend established thus far holds when the 2012 collections are evaluated, the prevalence of resistant phenotypes will make common waterhemp management in corn and soybean increasingly difficult. Recognize that this screen is with the postemergence application of these herbicides; there is a possibility the common waterhemp populations may respond differently to soil-applied herbicides. Furthermore, the heritability of resistance, particularly the HPPD inhibitor herbicides, will influence how quickly this phenotype emerges in common waterhemp. Regardless, these preliminary data indicate that better management of weeds in Iowa is of utmost importance and alternatives strategies must be quickly adopted in order to maintain effective weed management.

INCREASING CONCERNS OVER DISTRIBUTION PATTERNS OF GLYPHOSATE RESISTANT WEEDS IN KENTUCKY.

James R. Martin*[1], JD Green[2], William W. Witt[1]; [1]University of Kentucky, Princeton, KY, [2]University of Kentucky, Lexington, KY (166)

The emphasis of Roundup Ready technology in both soybean and corn are factors that contributed to the development of a number of glyphosate-resistant weeds in Kentucky. Examples of weeds not being controlled effectively with glyphosate include horseweed (*Conyza canadensis*), Palmer amaranth (*Amaranthus palmeri*), waterhemp (*Amaranthus tuberculatus* [syn *rudis*]), common ragweed (*Ambrosia artemisiifolia*), and volunteer corn (*Zea mays*). Of these weeds, the ones that cause great concern in Kentucky are horseweed, Palmer amaranth, and waterhemp. The presence of glyphosate-resistant horseweed in soybean was first reported in Trigg County in 2001. Within a few years, horseweed was observed throughout much of western Kentucky where the majority of soybean production occurs. A survey of Kentucky Extension agents in the fall of 2011 indicated horseweed was present in 57 of the 80 counties that report soybean production. The steady increase in number of soybean acres since 2007 in central Kentucky correlated with the spread of horseweed in this region of the state. The small achenes that are attached to a pappus of bristles enable the seed to be dispersed long distances by wind currents. Horseweed plants present along guardrails and similar non-crop areas also provide a source for seed to spread to nearby areas. Isolated problems with Palmer amaranth and waterhemp in western Kentucky occurred between 2005 and 2010. Excessive flooding during the springs of 2010 and 2011 caused a rapid spread of both pigweed species. Problems with Palmer amaranth and waterhemp were reported in several counties adjacent to major rivers including the Mississippi, Ohio, Cumberland, and Green Rivers. Several county extension agents reported that infestations of these pigweeds often occurred in fields within the floodplains. It is also believed that producers who had fields in both the floodplains and the upland areas spread weed seed with equipment, especially combines at time of harvest. An in depth survey sponsored by the Kentucky Soybean Promotion Board in 2012 involved collecting leaf samples of Palmer amaranth and waterhemp for analyzing for resistance to certain herbicides. Extension agents, dealers, consultants, and specialists made collections from 17 counties ranging from western part of the state to Northern Kentucky. A total of 340 samples from 76 fields were collected. Waterhemp was present in 7 counties that border the Ohio River. However, Palmer was present in 11 counties within the Purchase area along the Mississippi River; in the southern part of the Pennyrile region; and in one county in south central Kentucky. Henderson County along the Ohio River had both Palmer amaranth and waterhemp. One of the outcomes of this survey was that it brought attention to spreading of Palmer amaranth in diary operations that use cotton seed as a feed supplement. It appears these operations imported cotton seed that had been contaminated with Palmer amaranth seed. Cow manure containing Palmer amaranth seed was spread over corn fields used for silage, where massive populations of the weed developed. In order to combat the spread of glyphosate-resistant weeds, University of Kentucky weed scientists are working with the Kentucky Soybean Promotion Board and the United Soybean Board to help develop educational programs targeted at managing these problem weeds.

GLYPHOSATE-RESISTANT KOCHIA CONFIRMATION IN NORTH DAKOTA. Kirk A. Howatt*, Andrew N. Fillmore; NDSU, Fargo, ND (167)

Kochia with resistance to glyphosate was first confirmed in Kansas and since has been identified in several Midwestern states as well as southern Canada. Previously suspected North Dakota collections were controlled with glyphosate in greenhouse screening trials. Two samples were obtained from consultants during the 2011 season that were collected in fields that demonstrated exceptional survival to field applications of glyphosate. Greenhouse trials were conducted to evaluate the response of these collections and a susceptible line to glyphosate at rates of 420 to 6720 g ae/ha. Treatments were applied in 93 L/ha with a cabinet sprayer when kochia was 5 cm tall. Survival of the suspect plants was strong when treated with glyphosate at 840 g/ha and some plants survived to produce seed after treatment with 3360 g/ha. Kochia from these sites also demonstrated greater than expected survival after treatment with fluroxypyr at 140 g ae/ha or dicamba at 560 g ae/ha. To assess the scope of glyphosate-resistant kochia in North Dakota, kochia seed samples were solicited from growers, consultants, and extension agents from fields with lack of performance questions. More than 50 samples were received predominantly from eastern North Dakota. These were treated with glyphosate at 840 and 2520 g/ha glyphosate and 140 and 280 g/ha fluroxypyr to determine the distribution of glyphosate-resistant kochia in North Dakota.

CAN GROWERS MANAGE GLYPHOSATE RESISTANT KOCHIA? Curtis R. Thompson*, Dallas Peterson; Kansas State University, Manhattan, KS (168)

Kochia infests Kansas crops annually often requiring herbicide applications to effectively manage the problem. Kansas kochia populations have developed resistance to several herbicide modes of action including triazines and ALS inhibitors. A Stevens County, KS kochia population survived 0.75 lb ae glyphosate in greenhouse work was reported in 2008 at NCWSS. Since that time, glyphosate resistant kochia is wide spread across the western half of Kansas. Glyphosate resistance has complicated kochia management in crop production in Kansas. Dillie et.al. reported that at several locations across KS, CO, WY, and NE kochia begin emerging in March and that 90% of the kochia had emerged by late April. Personal observation suggests that many problems associated with unsuccessful control of glyphosate resistant kochia are linked to inadequate control of the initial dense kochia canopies which develop from March and April emerged kochia. Experiments were established in 2011 and 2012 to evaluate the effectiveness of herbicides applied in March preemergence to kochia for managing heavy kochia populations. Surface applied residual herbicides which effectively controlled early germinating kochia include, dicamba, atrazine, metribuzin, sulfentrazone, isoxaflutole, and various combinations of these herbicides. Additional experiments suggest that several herbicide programs involving the previously discussed herbicides applied preemergence in corn, sorghum, or soybean and postemergence in corn and sorghum controlled kochia especially following an effective early preplant March treatment. Growers can manage glyphosate resistant kochia, however it will involve March applied herbicides prior to kochia emergence, preemergence herbicides at crop planting, followed by effective postemergence herbicides. These effective programs will result in increased cost of production of crops grown in western Kansas.

ADJUVANTS AFFECT KOCHIA CONTROL WITH GLYPHOSATE. Phillip W. Stahlman*, Patrick W. Geier; Kansas State University, Hays, KS (169)

Field experiments were conducted at three sites in Kansas in 2012 to compare the effectiveness of water conditioning agents and herbicide adjuvants on the phytotoxicity of glyphosate to kochia. Treatments consisted of a factorial arrangement of unconditioned well water, dry spray-grade ammonium sulfate at 10 g L^{-1} (1% w/v), and liquid ammonium sulfate plus surfactant (Deliver) at 2.5% v/v. The ammonium sulfate products delivered the same amount of ammonium ion. Herbicide adjuvant products tested included a non-ionic surfactant (Activator 90) used at 0.5% v/v; a combination of buffering agents and non-ionic surfactants (Sur-Tec) used at 0.125% and 0.25% v/v; a petroleum-based crop oil concentrate (Agri-Dex) used at 1.0% v/v; and a modified vegetable oil surfactant blend (Dyne-Amic) used at 1.0% v/v. Adjuvants were added individually to a solution of an isopropyl amine salt of glyphosate at 628 g ae ha^{-1}. Spray volume was 120 L ha^{-1}. Susceptibility of the kochia populations to glyphosate varied among sites. Kochia at one site (Quinter) was susceptible, most plants at a second site (McCracken) exhibited low- to mid-level tolerance to glyphosate, and nearly all plants at the third site (Scott City) exhibited higher-level tolerance to glyphosate. No treatment controlled kochia by as much as 25% at the Scott City site at 21 days after treatment (DAT), confirming the ineffectiveness of adjuvants in overcoming resistance to glyphosate in kochia. At both the Quinter and McCracken sites, kochia control averaged across herbicide adjuvants was greater with the liquid ammonium sulfate-surfactant product compared to dry ammonium sulfate, especially at the McCracken site. Both forms of ammonium sulfate improved kochia control considerably compared to the no ammonium sulfate treatment. At Quinter, the glyphosate-susceptible site, kochia control 21 DAT averaged across water conditioning treatments was greater with either concentration of Sur-Tec compared to Activator 90 or Dyne-Amic, which were similarly effective. Agri-Dex was intermediate in effectiveness. At the McCracken site at 21 DAT, kochia control in decreasing order of effectiveness was: Sur-Tec 0.25% v/v > Sur-Tec 0.125% v/v = Agri-Dex > Activator 90 = Dyne-Amic.

COMMON LAMBSQUARTERS CONTROL: CHAPTER 3 - ADJUVANTS. Rich Zollinger*; North Dakota State University, Fargo, ND (170)

Herbicide labels are generally deficient in describing sufficient information to optimize herbicide activity through adjuvants. Glyphosate labels may restrict use of surfactants, state that no additional surfactant is needed, or allow use by voluntary action. Many weed species are 'easy-to-wet' and have high retention of the spray droplets. These species may not show a significant increase in herbicide activity through adjuvant enhancement in moderate environmental conditions and on small weeds that are not stressed. Many weeds are 'hard-to-wet' which decreases retention of spray droplet and reduces efficacy. Lambquarters and many grasses are 'hard-to-wet'. Control of 'hard-to-wet' species may increase if the most efficacious adjuvants were identified on herbicide labels and recommended at optimum rates. Several field and greenhouse studies were conducted over multiple years to observe adjuvant affect on Chenopodium species from herbicides. Increasing water volume had a slight effect in improving herbicide efficacy but addition of nonionic surfactants (NIS) that improved retention had a greater effect. Lambsquarters efficacy from a full-load glyphosate formulation varied widely with 13% (no NIS), to 78% (NIS at 1%). Several commercial NIS adjuvants were tested with glyphosate and control ranged from 10% to 78%. NIS adjuvants were applied with no-surfactant load, partial-load, and full-load glyphosate formulations and control ranged from 17% to 73%. Some NIS adjuvants that increased lambsquarters control in a no-load glyphosate showed reduced control when applied with partial- or full-load glyphosate formulations. NIS adjuvant enhancement was most pronounced when used with no- or partial-load glyphosate formulations but increased control was observed to a lesser extent when NIS was used with full-load formulations. The results show that control of lambsquarters may improve when effective NIS adjuvants are added at higher rates than commercially used with all formulations of glyphosate. NDSU Extension adjuvant use recommendations to growers have been changed to add NIS at 0.5% to 1% v/v for no-load, 0.25% to 0.5% v/v for partial-load, and 0.25% v/v for full-load glyphosate formulations.

MOST COMMON WEEDS IDENTIFIED IN GRAIN CROPS, FORAGES, AND TURFN THROUGH UNIVERSITY OF KENTUCKY'S WEED IDENTIFICATION CLINIC. JD Green*[1], James R. Martin[2], Aaron Laurent[1]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY (171)

The University of Kentucky Weed Science program provides a weed identification service available to clientele through the local county extension offices spread across the state. This clinic assists landowners, producers, consultants and other clientele with proper identification of weedy plants and recommended control strategies. Approximately 400 to 500 samples per season are submitted to the UK Weed Science Herbarium for identification. Samples are either mailed to the clinic or submitted as an electronic submission through direct emails and the UK digital consulting system. A digitized database was assembled that represents over 9800 plant samples examined over the past 25 years. This database can be used to search for the most common weeds associated with various habitats which includes the primary grain crops (i.e. corn, grain sorghum, soybean, wheat), forage crops (i.e. alfalfa, hayfields, and pastures), turf, and other environments. This database can also be used to look at trends of developing weed problems over time, as well as to map the presence of invasive plants at the county level across Kentucky. In Kentucky corn fields the ten most frequently identified plants over the past 25 years included broadleaf signalgrass (*Urochloa platyphylla*), various brome grasses (*Bromus* spp.), beaked panicum (*Panicum anceps*), common mugwort (*Artemisia vulgaris*), purpletop (*Tridens flavus*), Canada thistle (*Crisium arvense*), trumpetcreeper (*Campsis radicans*), cinnamon vine (*Discorea batatas*), bermudagrass (*Cynodon dactylon*), and fall panicum (*Panicum dichotomiflorum*). Other troublesome weeds included honeyvine milkweed (*Ampelamus albidus*), burcucumber (*Sicyos angulatus*), bigroot morningglory (*Ipomoea pandurata*), and Japanese knotweed (*Polygonum cuspidatum*). The ten most common soybean weeds were the brome grasses, prickly sida (*Sida spinosa*), barnyardgrass (*Echinochloa crus-galli*), sicklepod (*Senna obtusifolia*), eastern black nightshade (*Solanum ptychanthum*), broadleaf signalgrass, hophornbeam copperleaf (*Acalypha ostryifolia*), horseweed (*Conyza canadensis*), smooth pigweed (*Amaranthus hybridus*), and eclipta (*Eclipta prostrata*). The top five wheat weeds included the brome grasses (eg. smooth brome, field brome, and cheat), little barley (*Hordeum pusillum*), field pennycress (*Thlaspi arvense*), Italian ryegrass (*Lolium multiflorum*), and annual bluegrass (*Poa annua*). Forage crop weeds identified in grass pastures included lanceleaf ragweed (*Ambrosia bidentata*), annual marshelder (*Iva annua*), perilla mint (*Perilla frutescens*), brome grasses, tickclover (*Desmodium* spp.), buttercup (*Ranunculus* spp.), sericea lespedeza (*Lespedeza cuneata*), nodding spurge (*Chamaesyce nutans*), purpletop, and beaked panicum. In hayfields, additional weeds identified included sweet vernalgrass (*Anthoxanthum odoratum*), hemp dogbane (*Apocynum cannabinum*), common velvetgrass (*Holcus lanatus*), little barley, barnyardgrass, and yellow foxtail (*Setaria pumila*). Whereas, in alfalfa the most common weeds were hairy bittercress (*Cardamine hirsuta*), Philadelphia fleabane (*Erigeron philadelphicus*), common chickweed (*Stellaria media*), virginia copperleaf (*Acalypha virginica*), Italian ryegrass, and barnyardgrass. In turfgrass environments the ten most common weeds were bermudagrass, nimblewill (*Muhlenbergia shreberi*), ground ivy (*Glechoma hederacea*), Virginia buttonweed (*Diodia virginiana*), common lespedeza (*Lespedeza striata*), dallisgrass (*Paspalum* spp.), yellow nutsedge (*Cyperus esculentus*), annual bluegrass, common chickweed, and tall fescue (*Schedonorus arundinaceus*). Other weed species included creeping bentgrass (*Agrostis stolonifera*), large crabgrass (*Digitaria sanguinalis*), orchardgrass (*Dactylis glomerata*), star-of-bethlehem (*Ornithogalum umbellatum*), Italian ryegrass, hairy bittercress, and smooth crabgrass (*Digitaria ischaemum*).

TOLERANCE AND SELECTIVITY TO COPYRALID HERBICIDE ON RED RASPBERRIES VAR. “ENCORE”.

Constanza Echaiz*; The Ohio State University, Wooster, OH (172)

Raspberries (*Rubus ideaus*) are an important crop in Ohio with more than 450 acres and an enormous potential to expand the current acreage, based on the increasing demand. However, inadequate weed control is the major factor limiting raspberry production and profitability. Clopyralid is an auxin herbicide able to provide efficient Canada Thisle (*Cirsium arvense*) control. Field experiments were conducted during 2010 and 2011 at Wooster, Ohio in established red raspberries var. “Encore”. Clopyralid at 0.14 and 0.28 kg ai ha-1 was applied in late spring (June), post harvest (August), early fall (September) and late fall (November) applications. The injury symptom associated with all applications timings was slight chlorosis (0-10%) but both floricanes and primocanes were able to recover after a couple of weeks. Injury symptoms were not detected the following spring, planting vigor and yields were not affected. Our results indicate that clopyralid is an efficient and safe option for control of Canada thistle in established red raspberries.

PYROXASULFONE FOR WEED CONTROL IN VEGETABLE CROPS.

Bernard H. Zandstra*[1], Jarrod J. Morrice[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, Lansing, MI (173)

Pyroxasulfone is a new field crop herbicide which may have utility in vegetables. Pyroxasulfone inhibits very long chain fatty acids and is classified for mode of action in WSSA Group 15 and HRAC K3. Pyroxasulfone was applied to various seeded or transplanted vegetable crops at rates of 0.032 - 0.36 lb ai/acre. Crops were grown on mineral and muck soil. Pyroxasulfone was applied to basil on sandy loam soil at 0.05 lb/a. Basil was sensitive to pyroxasulfone and had severe yield reduction. Pyroxasulfone was applied to cilantro and dill on a sandy loam soil at 0.05 lb/a. Cilantro was tolerant and dill yield was reduced 50%. Snap bean was treated with 0.09 lb/a pyroxasulfone preemergence on sandy loam. It did not control most weeds at that rate and snap bean yield was reduced. Red beets, sugar beets, and Swiss chard were treated with pyroxasulfone at 0.032 lb/a. At this rate it gave insufficient weed control and caused yield reduction in all three crops. Pyroxasulfone was applied pretransplant to cabbage and cauliflower transplants at 0.09 lb/a. It caused 50% yield reduction in cabbage and 40% yield reduction in cauliflower. It gave good weed control for about 4 weeks but then lost control of broadleaves. Pyroxasulfone was applied to carrot preemergence at 0.09 and 0.18 lb/a on muck soil. Carrots were stunted early but recovered and yield was similar to control treatments. Pyroxasulfone was applied to celery transplants at 0.18 and 0.36 lb/a after transplanting. Celery was stunted early but outgrew the injury. Celery yield was reduced by 0.36 lb/a pyroxasulfone. Pretransplant application was safer than posttransplant application in one trial, and posttransplant treatments had higher yield in another trial. In sweet corn, pyroxasulfone at 0.18 lb/a on loam soil caused minor crop stunting and moderate yield reduction. Weed control was good early in the season. In Romaine lettuce, pyroxasulfone applied preemergence at 0.05/a lb on muck soil caused minor crop stunting but yield was not reduced. It did not control common purslane. In dry bulb onions on sandy soil, pyroxasulfone at 0.09 or 0.18 lb/a applied preemergence caused crop injury early and >50% yield reduction. Pyroxasulfone applied preemergence on onion on muck soil at 0.18 and 0.36 lb/a caused moderate crop stunting and 40% yield reduction at 0.18 lb/a but no yield reduction at 0.36 lb/a, probably because of better weed control. It provided moderate ladysthumb control and good redroot pigweed control. On seeded green onion on sandy soil, pyroxasulfone at 0.18 lb caused serious crop injury and yield loss. On muck soil it caused moderate stunting on seeded green onion at 0.18 and 0.36 lb, and slight yield reduction at the lower rate. On established chives, pyroxasulfone at 0.18 lb/a caused slight stunting and moderate yield reduction in the first harvest. Second and third harvests were similar to other treatments. In banana and cherry pepper, pyroxasulfone at 0.09 lb/a applied pretransplant caused stunting and yield reduction for both types of pepper. Pyroxasulfone at 0.05 lb caused slight crop stunting of pumpkin, buttercup squash, and hubbard squash. Pumpkin and hubbard squash had good yields but buttercup squash yield was reduced. It appears that pyroxasulfone may be a useful herbicide for several vegetable crops.

WEED CONTROL IN APPLE WITH OLD AND NEW HERBICIDES.

Jarrod J. Morrice*[1], Bernard H. Zandstra[2]; [1]Michigan State University, Lansing, MI, [2]Michigan State University, East Lansing, MI (174)

Several long-residual herbicides have been developed recently for use in tree fruit crops. Use of these herbicides improves the potential for season-long weed control in perennial crops. Preemergence herbicides were applied in November 2011 and April 2012 to 6-year-old dwarf apple trees. Glyphosate at 1.35 lb/a was added to all fall and spring treatments to kill emerged weeds. No injury to apple trees was apparent from any treatment. Fall applied flumioxazin at 0.383 lb/a suppressed most weeds into July. Flumioxazin did not control dandelion and white clover. Barnyardgrass and large crabgrass were controlled through June but germinated in July. Fall panicum and yellow foxtail germinated in August. Horseweed control was maintained all season by fall and spring applications of flumioxazin plus glyphosate. Fall-applied indaziflam at 0.065 lb/a suppressed most annual broadleaves and grasses through August. Fall-applied indaziflam did not control white clover or dandelion. It maintained control of large crabgrass and yellow foxtail into September. Spring-applied indaziflam controlled dandelion. Fall-applied isoxaben at 1 lb/a did not control annual bluegrass, and it was weak on common groundsel, common lambsquarters, dandelion, and white clover. Spring applied isoxaben was more effective for broadleaf weed control. It was weak against annual grasses. Fall applied flazasulfuron at 0.045 lb/a was weak against annual bluegrass and horseweed. It controlled dandelion until July 1. It lost control of annual grasses by September. Spring applied flazasulfuron controlled dandelion all season. Fall applied oxyfluorfen plus penoxsulam (Pindar) at 1.5 lb/a suppressed all weeds except dandelion until July 1. Horseweed, white clover, barnyardgrass and large crabgrass emerged in July. Spring-applied Pindar at 1.5 lb/a was slightly more effective than fall-applied Pindar. Spring applied Pindar was less effective against barnyardgrass. Large crabgrass emerged in late July in all Pindar plots. Neither fall nor spring-applied Pindar controlled fall panicum. Fall applied rimsulfuron at 0.063 lb/a suppressed most annual weeds until July. By late July common mallow, dandelion, horseweed, prostrate knotweed, and common groundsel had emerged. Spring applied rimsulfuron was more effective against most annual weeds. Fall- and spring-applied terbacil at 2.4 lb/a provided excellent control of all annual weeds except common groundsel. In late July, large crabgrass germinated in the terbacil treatments. Wild carrot was difficult to control with most herbicides. Oryzalin at 3 lb/a plus rimsulfuron at 0.063 lb/a provided good control through July. Pendimethalin at 3.8 lb/a plus rimsulfuron at 0.063 lb/a also was effective. Flazasulfuron at 0.045 lb/a and terbacil at 2.4 lb/a provided good wild carrot control. Application of new herbicides will improve weed control in apples and reduce potential for weed resistance.

IMPACT OF SIMULATED SYNTHETIC AUXIN HERBICIDE DRIFT ON VEGETABLE CROPS.

Jed Colquhoun*, Daniel Heider, Richard Rittmeyer; University of Wisconsin, Madison, WI (175)

The potential introduction of agronomic crops resistant to synthetic auxin herbicides has stimulated a renewed interest in the potential off-target risk posed by these herbicides to nearby specialty crops. With this in mind, field research was conducted in 2011 and 2012 to determine the effect of simulated synthetic auxin drift on potatoes and snap (green) beans. In potatoes, simulated dicamba drift was evaluated at three rates (1.4, 4.2 and 7.0 g ae/ha) and two timings. In snap beans, 2,4-D and dicamba were evaluated individually at the same rates described above but at one application timing. In 2011, when dicamba was applied to 25 cm tall potatoes, visual injury 10, 24 and 30 days after treatment (DAT) increased with application rate, but by 38 DAT injury was greater than in the non-treated control only at the highest application rate. Potato tuber size distribution was variable and total yield did not differ among treatments and the non-treated control in 2011. In 2012, tuber size distribution was again variable, but more non-marketable cull potatoes were harvested where dicamba was applied at the highest rate to 25 cm potato plants than from any other treatment. In snap beans in 2011, injury from dicamba 7 DAT ranged from 19% at the low application rate to 45% at the high application rate. By 18 DAT in 2011, injury from 2,4-D was similar to the non-treated control. However, early-season injury in 2011 delayed snap bean flowering and reduced crop yield compared to the non-treated control for all treatments except where the lowest rate of 2,4-D was applied. Snap bean injury from dicamba was greater than that from 2,4-D at all visual rating timings in 2011 and two of three rating timings in 2012, and crop yield was reduced compared to where 2,4-D was applied and the non-treated control in both years.

INTERACTIONS BETWEEN CHLORACETAMIDE AND PROTOPORPHYRINOGEN OXIDASE-INHIBITING HERBICIDES IN COLE CROPS. Darren E. Robinson*, Kristen E. McNaughton; University of Guelph, Ridgetown, ON (176)

The objective of this study was to determine the effect of tank-mixing three protoporphyrinogen oxidase-inhibiting herbicides (ie. flumioxazin, oxyflourfen and sulfentrazone) with s-metolachlor applied pre-transplant (PRE-T) or 1 day after transplanting (POST-T) on weed control and tolerance of broccoli. These trials were conducted at two locations from 2010 to 2012 at the University of Guelph, Ridgetown Campus on a loam or sandy loam soil with approximately 3.8 to 5.3% organic matter. Percent injury was rated 7, 14 and 28 days after transplanting, and percent control of common lambsquarters, velvetleaf, large crabgrass and redroot pigweed were determined 56 DAT. Marketable head size and marketable yield of broccoli were determined at harvest. No treatment by soil type or year interaction was detected for weed control and crop tolerance, so data were combined over soil types and years for analysis. However, application timing (PRE-T vs. POST-T) and herbicide treatment did affect weed control and crop tolerance of the tank mix treatments. Control of common lambsquarters, velvetleaf, large crabgrass and redroot pigweed was greater when the tank mixes were applied POST-T than PRE-T. The POST-T tank mix of flumioxazin + s-metolachlor provided better control of common lambsquarters, velvetleaf and redroot pigweed than the POST-T tank-mixes of sulfentrazone + s-metolachlor and oxyfluorfen + s-metolachlor. Crabgrass control was similar among the three POST-T tank-mixes. Percent injury, marketable broccoli head size and marketable yield were less than the untreated check in flumioxazin + s-metolachor treatments when applied POST-T. None of the other treatments reduced the marketable head size or yield of broccoli.

EFFECT OF SIMULATED GLYPHOSATE DRIFT TO FOUR POTATO PROCESSING CULTIVARS. Harlene M. Hatterman-Valenti*[1], Collin Auwarter[2]; [1]North Dakota State University, Fargo, ND, [2]NDSU, Fargo, ND (177)

Field research was conducted at the Northern Plains Potato Grower’s Association irrigation research site near Inkster, ND to evaluate the current year potato injury from simulated glyphosate drift at the tuber initiation (TI), early tuber bulking (EB), and late tuber bulking stage (LB) for four processing potato cultivars: Russet Burbank, Umatilla, Ranger Russet and Bannock. Seed pieces were planted on May 24. Glyphosate was applied at rates one-quarter, one-eighth, and one-sixteenth the lowest labeled rate of 0.47 lb/A during the TI and EB stages. During the LB stage glyphosate was applied at the one-quarter, one-eighth, and one-sixteenth the standard use rate of 0.95 lb/A. Ammonium sulfate was tank mixed at a rate of 4 lbs/100 gal. The treatments were applied using a CO_2-pressurized ATV sprayer with a spray boom extended to cover treated rows. The sprayer output was 20 GPA at 40 psi using 8002 flat fan nozzles. Potatoes yielded well throughout the trial averaging 438 cwt/A amongst the four processing cultivars. Russet Burbank appeared to be most sensitive to glyphosate drift during EB with the highest rate causing approximately 20% yield reduction compared to the lower rates. The same was true for Umatilla with the highest rate causing approximately 19% yield reduction compared to the lowest rate at EB. Bannock appeared to be most sensitive to glyphosate during TI with a total yield of 354 cwt/A when treated with the highest rate of glyphosate. This was approximately a 13% yield reduction compared to the lower rates. Ranger Russet appeared to be the least sensitive to glyphosate with a yield range between 442 and 487 cwt/A for all treatments. Daughter tubers have been saved and will be planted in 2013 to see if glyphosate movement into daughter tubers used for seed varied amongst cultivars.

SOIL TYPE AND ROOTING DEPTH EFFECTS ON CREEPING BENTGRASS TOLERANCE TO AMICARBAZONE AND METHIOZOLIN.

James Brosnan*, Gregory K. Breeden, Sara Calvache, John C. Sorochan; University of Tennessee, Knoxville, TN (178)

Amicarbazone and methiozolin are herbicides with efficacy for annual bluegrass (*Poa annua* L.) control in creeping bentgrass (*Agrostis stolonifera* L.). Greenhouse research was conducted at the University of Tennessee to determine the effects of rooting depth and soil type on creeping bentgrass injury with amicarbazone and methiozolin. Additional field studies in Knoxville, TN and Lubbock, TX evaluated annual bluegrass control efficacy with methiozolin on golf course putting greens varying in soil texture. In the greenhouse, 'Penncross' creeping bentgrass was established in sand- or soil-based rootzones using mini-rhizotrons. Plants were treated with amicarbazone (49, 98, 196 g ha^{-1}) or methiozolin (500, 1000, 2000 g ha^{-1}) once root growth reached depths of 5, 10, and 15 cm. Amicarbazone was more injurious than methiozolin in both rootzones. Creeping bentgrass injury with amicarbazone measured 38% in the sand-based rootzone compared to 62% in soil. This injury was accompanied by 54 to 69% reductions in root length density in the sand-based rootzone and 42 to 81% reductions in soil. Methiozolin resulted in ≤ 12% creeping bentgrass injury, regardless of rootzone type or application rate, and reduced root length density 0 to 25%. Amicarbazone applications to plants rooted to 15 cm were less injurious than those rooted to 5 and 10 cm depths. Responses indicate that methiozolin is less injurious to creeping bentgrass than amicarbazone and that rooting depth and soil type affect creeping bentgrass injury with amicarbazone. Field experiments evaluated annual bluegrass control efficacy with methiozolin using two application rates (500 and 1000 g ha^{-1}) and six application regimes [October, November, December, October followed by (fb) November, November fb December, and October fb November fb December] on sand- and soil-based putting greens. Annual bluegrass control with methiozolin at 1000 g ha^{-1} on sand-based greens ranged from 70 to 72% compared to 87 to 89% on soil-based greens. Treatment at 500 g ha^{-1} controlled annual bluegrass 57 to 64% on sand-based greens compared to 72 to 80% on soil-based greens. Most sequential methiozolin application regimes controlled annual bluegrass greater than single applications. On sand-based greens, sequential application programs controlled annual bluegrass 70 to 79% compared to 85 to 92% on soil-based greens. Responses indicate that soil type and rooting depth affect the activity of amicarbazone and methiozolin applications for weed control on creeping bentgrass putting greens.

ANNUAL GRASSY WEED CONTROL IN COOL-SEASON TURF WITH TOPRAMEZONE.

Gregory K. Breeden*[1], James Brosnan[1], Aaron J. Patton[2], Dan V. Weisenberger[3]; [1]University of Tennessee, Knoxville, TN, [2]Purdue University, W. Lafayette, IN, [3]Purdue University, Lafayette, IN (179)

Topramezone is a new hydroxyphenylpyruvate dioxygenase (HPPD) inhibiting herbicide being evaluated for use in cool-season turfgrass. Data describing cool-season turfgrass tolerance and weed control efficacy with topramezone are limited. Separate trials were conducted in 2012 evaluating the efficacy of topramezone applications for smooth crabgrass (*Digitaria ischaemum*) control. The site for each trial was a mature stand of tall fescue (*Festuca arundinacea*) maintained as a golf course rough at the East Tennessee Research and Education Center-Plant Sciences Unit (Knoxville, TN) and a mature stand of Kentucky bluegrass (*Poa pratensis*) at the William H. Daniel Turfgrass Research and Diagnostic Center (West Lafayette, IN). Plots were 1.5 by 3 m in Tennessee and 1.5 by 1.5 m in Indiana at each location were arranged in a randomized complete block design with three replications. Treatments included the factorial combination of topramezone (12.3 g ha^{-1} and 24.5 g ha^{-1}) and triclopyr (1120 g ha^{-1}) applied at three stages of smooth crabgrass growth: 1-3 leaf, 1-3 tiller and 5-7 tiller. An untreated control was included for comparison. All herbicides were applied with a CO_2 powered boom sprayer calibrated to deliver 281 L ha^{-1} utilizing four, flat-fan, 8002 nozzles at 124 kPa, configured to provide a 1.5-m spray swath. Tall fescue injury, smooth crabgrass bleaching, and smooth crabgrass control were evaluated visually utilizing a 0 (e.g., no turf injury, control, or bleaching) to 100% (e.g., complete kill) scale at 1, 2, 4, 6, and 9 weeks after treatment (WAT). At no time during these studies was tall fescue injury observed at either location. In Tennessee, applications of topramezone (12.3 g ha^{-1} and 24.5 g ha^{-1}) + triclopyr at the 1-3 leaf stage controlled smooth crabgrass ≥ 87% 4 WAT. When applied at the 1-3 tiller stage, all topramezone and topramezone + triclopyr treatments controlled smooth crabgrass ≥ 90% 4 WAT. Topramezone (12.3 and 24.5 g ha^{-1}) applied 1-3 tiller bleached crabgrass ≥ 30% 1 WAT and ≥ 8% 2 WAT. The addition of triclopyr to topramezone at this timing reduced bleaching to 0% 1 and 2 WAT. Applied at the 5-7 tiller stage, topramezone (24.5 g ha^{-1}) and topramezone (24.5 g ha^{-1}) + triclopyr controlled smooth crabgrass ≥ 93% 4 WAT; at 12.3 g ha^{-1} these treatments controlled smooth crabgrass ≥ 70%. Both rates of topramezone applied at the 5-7 tiller stage bleached crabgrass ≥ 36% 1 WAT and ≥ 20% 2 WAT. However, the addition of triclopyr to topramezone reduced bleaching to ≤ 5% 1 and 2 WAT. In Indiana, applications of topramezone (12.3 g ha^{-1} and 24.5 g ha^{-1}) + triclopyr at the 1-3 leaf stage controlled smooth crabgrass ≥ 78% 4 WAT. All treatments applied at the 1-3 and 5-7 tiller stages controlled smooth crabgrass ≤ 45% 4 WAT. Topramezone (12.3 and 24.5 g ha^{-1}) applied at the 1-3 tiller stage bleached smooth crabgrass ≥ 23% 1 WAT and ≥ 25% 2 WAT. The addition of triclopyr to topramezone at this timing reduced bleaching to ≤ 13% 1 and 2 WAT. Bleaching responses at the 5-7 tiller stage were similar. Despite the activity of topramezone and reductions in bleaching observed with applications of topramezone + triclopyr at the 1-3 leaf, 1-3 tiller, and 5-7 tiller stages of growth, smooth crabgrass control measured ≤ 75% with all treatments by 9 WAT except topramezone (24.5 g ha^{-1}) + triclopyr applied at the 1-3 tiller stage in Tennessee. These responses illustrate that sequential applications of these herbicides will be required for effective postemergence smooth crabgrass control.

CREEPING BENTGRASS (*AGROSTIS STOLONIFERA*) TOLERANCE TO TOPRAMEZONE IN COMBINATION WITH VARIOUS HERBICIDE SAFENERS.

Matthew T. Elmore*[1], James Brosnan[1], Gregory R. Armel[2], Michael Barrett[3], Gregory K. Breeden[1]; [1]University of Tennessee, Knoxville, TN, [2]BASF, Research Triangel Park, NC, [3]University of Kentucky, Lexington, KY (180)

Creeping bentgrass (CBG) (*Agrostis stolonifera* L.) is the most widely used cool-season turfgrass species on golf course fairways and tees in the United States. Despite widespread popularity, CBG is tolerant of few postemergence herbicides. Preliminary research indicates CBG has some tolerance to the HPPD-inhibiting herbicide topramezone, but improved tolerance is desirable. Two experiments were conducted at the University of Tennessee (Knoxville, TN) to evaluate safeners as a means to enhance CBG tolerance to topramezone. In Experiment 1, topramezone (37 g ha^{-1}) was applied alone or in combination with the herbicide safeners naphthalic anhydride (NA) and isoxadifen-ethyl. Safeners were applied on the day of herbicide application or 3 days prior to herbicide application in a 5:1 or 10:1 safener:herbicide ratio. All treatments were applied with NIS at 0.25% v/v. Treatments were applied with a water carrier at 221 L ha^{-1} using a spray chamber to mature CBG grown in 6 cm cone-tainers filled with a peat moss, perlite vermiculite growing medium. Plants were maintained in a greenhouse under ambient light. The experiment was repeated in time with treatments in each run applied on February 10 and June 1, 2012. Treatments were evaluated visually on a 0 (no injury) to 100% (complete control) scale at 7, 14 and 21 days after treatment (DAT). Plants were clipped to a 1.25 cm height at 21 DAT, verdure was collected, dried and weighed to determine biomass. Data were analyzed in a completely randomized factorial design with three replications in SAS 9.3 ($\alpha \leq 0.05$). Application of NA and isoxadifen reduced injury from topramezone 14 DAT. The effect of safener application timing and safener rate were not significant in either run. Therefore, it was determined that the lowest safener rate (5:1 safener:herbicide) applied at the time of herbicide application would be used in Experiment 2. Using the same methodology, benoxacor, cloquinctocet-mexyl, fenchlorazole-ethyl, isoxadifen-ethyl, NA, and mefenpyr-diethyl were investigated to determine their ability to reduce CBG injury from topramezone application in Experiment 2. Cloquintocet-mexyl reduced CBG injury from topramezone (37 g ha^{-1}) 7 and 14 DAT. Additional studies are underway evaluating cloquintocet-mexyl effects on CBG injury and weed control with topramezone in both greenhouse and field settings.

ZOYSIAGRASS SEEDHEAD SUPPRESSION WITH IMAZAMOX.

James Brosnan*[1], Gregory K. Breeden[1], Aaron J. Patton[2], Dan V. Weisenberger[3]; [1]University of Tennessee, Knoxville, TN, [2]Purdue University, W. Lafayette, IN, [3]Purdue University, Lafayette, IN (181)

Options for suppressing zoysiagrass (*Zoysia* spp.) seedheads in managed turfgrass systems are limited and traditional plant growth regulators are ineffective at controlling zoysiagrass seedheads. Experiments were conducted in 2010 and 2011 evaluating the use of imazamox (26, 52, and 70 g ha^{-1}) for 'Zenith' and 'Meyer' zoysiagrass (*Zoysia japonica*) seedhead suppression and growth regulation compared to imazapic (52 g ha^{-1}) at the University of Tennessee (Knoxville, TN) and Purdue University (West Lafayette, IN). Sequential applications at a 21 day interval of imazamox and imazapic at ≥ 52 g ha^{-1} suppressed 'Zenith' zoysiagrass seedheads ≥ 95% 2 to 6 weeks after initial treatment (WAIT) each year. Slight injury (< 10%) was observed with these treatments; however, effective seedhead suppression resulted in increased green color from 8 to 15 WAIT each year. Relative chlorophyll index values for imazamox and imazapic treated plots ranged from 100 to 147% of the untreated control in 2010 and 89 to 125% of the untreated control in 2011. On Meyer zoysiagrass, imazamox and imazapic at ≥ 52 g ha^{-1} reduced seedhead counts greater than 90% in Tennessee and Indiana. However, significant (>25%) injury was reported with these treatments in Indiana. Additional research was conducted in 2012 evaluating the effects of application timing on Meyer zoysiagrass tolerance to imazamox and imazapic applications for seedhead suppression. Treatments included imazamox (26 and 52 g ha^{-1}) and imazapic (52 g ha^{-1}) alone and in combination with a soluble fertilizer containing nitrogen (15%) and non-chelated iron (6%) at 1.95 kg Fe ha^{-1}. Treatments were applied when 50, 100, 150, and 250 growing degree days (GDD) had been accumulated in Knoxville, TN and West Lafayette, IN. GDDs were calculated using a 10°C base beginning January 1st at each location. An untreated check was included for comparison. Minimal differences in Meyer zoysiagrass injury were detected between application timings in Tennessee. At 21 days after treatment (DAT), injury ranged from 0 to 10% regardless of application timing. In Indiana, applications at 250 GDD were more injurious than other application timings. Injury ranged from 0 to 16%. Injury was accompanied by reductions in green color compared to the untreated check at both locations. Inclusion of nitrogen and non-chelated iron reduced injury and mitigated reductions in color observed with most imazmox and imazapic treatments regardless of application timing. Applications at 100 and 150 GDD suppressed seedheads greater than treatments applied at 50 or 250 GDD in TN. Few applications effectively reduced seedheads in Indiana regardless of ingredient, timing, or iron, which possibly was due to our single application treatment design as previous research with sequential applications effectively reduced seedheads. Inclusion of nitrogen and non-chelated iron reduced seedhead suppression with imazamox (52 g ha^{-1}) and imazapic at all timings in Tennessee. This antagonism from iron was less evident in Indiana although it was evident in an adjacent and related experiment when sequential imazamox applications were made at a 21 day interval. Future research should evaluate environmental parameters trigging zoysiagrass flowering under field conditions to further refine programs and timings for seedhead suppression.

SAFETY OF LABELED HERBICIDES FOR BROADLEAF WEED CONTROL IN CREEPING BENTGRASS PUTTING GREENS.

Aaron J. Patton*[1], Dan V. Weisenberger[2], Gregory K. Breeden[3], James Brosnan[3]; [1]Purdue University, W. Lafayette, IN, [2]Purdue University, Lafayette, IN, [3]University of Tennessee, Knoxville, TN (182)

While most broadleaf weeds cannot survive at mowing heights used to maintain putting greens, species such as white clover (*Trifolium repens*), mouse-ear chickweed (*Cerastium vulgatum*), and prostrate spurge (*Euphorbia supina*) can persist even with the use of sound management practices. Many golf course superintendents are hesitant to use herbicides on their putting greens for fear that turfgrass injury might occur. The objective of this experiment was to determine the safety of postemergence broadleaf herbicides on putting green height creeping bentgrass (*Agrostis stolonifera*) turf. The experiment was conducted twice at the W.H. Daniel Turfgrass Research and Diagnostic Center in W. Lafayette, IN and also twice at the East Tennessee Research and Education Center in Knoxville, TN. Sites were creeping bentgrass putting greens grown on a USGA specification sand in IN and in TN the site was a soil-based green frequently topdressed with a USGA specification sand. The locations were mown at 3.5 mm and 4.5 mm in IN and TN, respectively. Plots were treated with herbicide on 24 Oct 2011 and an adjacent location on 22 May 2012 in Indiana and on 17 Oct 2011 and an adjacent location on 1 May 2012 in TN. Experimental design was randomized complete block with three replications and an individual plot size of 1.5 by 1.5 m in IN and 1.5 by 3.0 m in TN. The herbicides were applied in 814 L ha^{-1} water at 207 kPa with CO_2 pressurized boom sprayer equipped with an XR8002VS flat-fan nozzle at both locations. Herbicides included in this study were all labeled for use on creeping bentgrass putting greens and applied at the putting green label rate and at a rate 2x the label rate. One exception to this was in the Oct 2011 application timing in TN where only the label rate was applied. Herbicide treatments and their labeled putting green rate in liters product per hectare included 4-Speed (2.1 L ha^{-1}), 4-Speed XT (2.1 L ha^{-1}), Banvel (1.2 L ha^{-1}), Mecomec 2.5 (4.7 L ha^{-1}), Quicksilver T&O (0.5 L ha^{-1}), Trimec Bentgrass (3.2 L ha^{-1}), Trimec Classic (2.1 L ha^{-1}), Trimec Encore (2.1 L ha^{-1}), and Trimec Southern (2.3 L ha^{-1}). An untreated check was included for comparison. Injury to creeping bentgrass and turf quality data were collected. All data were analyzed using SAS (SAS Institute, Inc). Means were separated using Fisher's protected least significant difference when F tests were significant at α=0.05. Some injury was observed from fall treatments on creeping bentgrass putting greens in IN but injury levels were acceptable (≥ 7, on a scale of 9-1, where 9= no injury) for all treatments including herbicides applied at a 2x rate. Minor injury occurred from treatments at labeled and 2x rates. The herbicides 4-Speed, 4-Speed XT, Banvel, Trimec Bentgrass, Trimec Encore, and Trimec Southern were among the treatments causing minor injury. In TN, injury was minimal (<7%, on a scale of 0-100%, where 0%= no injury) and transient from labeled application rates with minor injury visible only from Quicksilver, 4-Speed, and 4-Speed XT. There were no differences in turf quality among treatments in Indiana or Tennessee. These results suggest that broadleaf herbicides labeled for putting green use can be safely applied in the fall without fear of causing unacceptable injury. We repeated the experiment in May 2012 to determine if more injury might be expected from late spring and summer applications during warmer temperatures. More injury was observed at both locations from May 2012 applications than Oct 2011 applications. Applications at label rates did not cause unacceptable injury when applied in IN in May, but 2x rates of Banvel, 4-Speed XT, and Trimec Southern did cause unacceptable injury 1 week after application (WAA) that was transient and was acceptable by 2WAA. Results were similar in TN with Banvel, 4-Speed XT, and Trimec Southern applied at the 2x rate also causing the most injury (11-18%) and with injury remaining >10% at 2WAA. Injury was highest at the labeled application rate in TN from Banvel (10%, 2WAA) but other products such as Mecomec, Quicksilver, Trimec Bentgrass, Trimec Classic, and Trimec Encore had <5% injury when applied at the labeled rate in May in TN and these same applications in Indiana also produced little to no injury. These results suggest that 1) broadleaf herbicides labeled for putting green use can be safely applied at labeled rates in the spring, 2) some herbicides are safer than others, and 3) unacceptable injury can occur from spot applications if herbicides are overdosed.

COMMON HONEYLOCUST CONTROL IN KANSAS. Walter H. Fick*; Kansas State University, Manhattan, KS (183)

Common honeylocust (*Gleditsia triacanthos*) is a native leguminous tree found throughout most of the U.S. Trees can reach 15 to 25 m in height and are commonly found along streams, rich bottomlands, rocky hillsides, fence rows, and pastures. Common honeylocust is a prolific resprouter and has the ability to spread quickly. The objective of the study was to determine the efficacy of eight foliar and five basal treatments applied for common honeylocust control. Two study sites were selected in Pottawatomie County, Kansas. Trees were 1 to 3.5 m tall. The foliar treatments were applied in 467 L ha^{-1} spray solutions using a backpack sprayer. A non-ionic surfactant at 0.25% was added to each foliar treatment. A total of 14 to 27 trees per treatment were foliar sprayed on July 21, 2011. Basal treatments were applied with diesel fuel as a carrier to 7 to 18 trees per treatment in mid to late November, 2011. Mortality was determined from all treatments the growing season after application. Chi square analysis was used to determine differences among treatments at the 0.05 level of significance. Control of common honeylocust was not different between locations for any herbicide. The only foliar treatment providing 100% control was aminocyclopyrachlor + metsulfuron at 0.9 + 0.2 g L^{-1}. Other treatments providing greater than 90% control included picloram + fluroxypyr (0.4 + 0.4 g L^{-1} and 0.8 +0.8 g L^{-1}), aminopyralid (0.3 g L^{-1}), and picloram + 2,4-D + triclopyr (0.65 + 2.4 + 1.2 g L^{-1}). Triclopyr (2.4 g L^{-1}), triclopyr + fluroxypyr (1.8 + 0.6 g L^{-1}), and picloram + 2,4-D (0.65 + 2.4 g L^{-1}) all provided about 82% control of common honeylocust treated on July 21. Basal treatments were not different (P>0.05). Triclopyr (48 and 120 g L^{-1}), triclopyr + fluroxypyr (45 + 15 g L^{-1} and 90 + 30 g L^{-1}), and triclopyr + 2,4-D (4.8 + 9.6 g L^{-1}) all provided greater than 92% control of common honeylocust treated with basal sprays in November 2011.

EFFECT OF CANADA THISTLE MANAGEMENT STRATEGIES ON FORAGE AVAILABILITY AND UTILIZATION IN ROTATIONALLY GRAZED PASTURES. Mark J. Renz*[1], Anders Gurda[2]; [1]University of Wisconsin Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI (184)

Canada thistle (*Cirsium arvense*) has been identified as a problem weed in Wisconsin pastures. It can reduce forage yield and utilization, both of which can have a negative impact on animal performance. Abatement typically involves the use of herbicides, but herbicides also remove clovers, which are highly desired in Wisconsin pastures. Others have recommended grazing methods such as high intensity low frequency grazing (Mob grazing) to control Canada thistle, but effectiveness on Canada thistle and resulting productivity and utilization have not been directly compared to herbicide methods. The objectives of this study are to 1) compare the effectiveness of rotational grazing with and without an herbicide to Mob grazing on Canada thistle suppression and 2) document differences in forage production and utilization. Research is being conducted on three separate pastures in Wisconsin that range in forage composition and productivity. At each site paddocks are arranged in a randomized complete block design consisting of four replications. Aminopyralid + 2,4-D (120 + 972 g ae ha^{-1}) was applied the fall of 2011 as the herbicide treatment. Rotationally grazed treatments were grazed 3-4 times in 2012 depending on the pasture when forage reached 20-36 cm, while Mob grazed plots were grazed twice when grasses were > 36 cm and Canada thistle was in the flower bud to flowering stage. All treatment plots were grazed to a 10 cm residual and allowed to recover until the appropriate timing before repeating the grazing treatment. Through July forage productivity was similar between the rotationally grazed control and mob treatment while the herbicide treatment had 28% less forage in the pasture with the largest proportion of clover. In contrast, the other two pastures with lower clover populations had 33 and 66% more forage available in the Mob treatment through July compared to other treatments. Canada thistle and clover compromised <1% of the biomass in the herbicide treated plots, while clover compromised 15-30% in other treatments in two of the three pastures through July. Utilization of Canada thistle was greater in the mob treatment compared to the other treatments; however, grass utilization through July differed depending on the pasture. The mob treatment utilized the most grass in the pastures with low to moderate clover populations and reduced productivity whereas the mob treatment utilized the least in the most productive pasture with high clover populations. Canada thistle density one year after herbicide application was reduced by both herbicide application (63, 77 and 98%) and mob grazing (77, 78, and 97%) compared to the rotationally grazed treatment. While additional monitoring in 2013 is needed, results suggest that Mob grazing is a viable alternative to managing Canada thistle in pastures in the upper Midwest. Productivity and utilization for the entire field season will be presented.

HPPD RESISTANCE TESTING IN THE MIDWEST-PRELIMINARY FIELD BIOASSAY RESULTS. Brent Philbrook*[1], Thomas Wilde[2], Roland Beffa[2], Thomas Kleven[3], Harry J. Strek[2]; [1]Bayer CropScience, White Heath, IL, [2]Bayer CropScience, Frankfurt, Germany, [3]Bayer CropScience, Sabin, MN (186)

Waterhemp (*Amaranthus tuberculatus* (MoQ.) Sauer) is an annual weed reducing the yield of several crops including maize and soybean and is particularly present in the Midwestern United States. Palmer amaranth (*Amaranthus palmer* S. Wats) is a common competitive weed often found in cotton and soybean fields in the Southern United States. The high reproduction potential of both weeds and their obligate outcrossing as dioecious species make them especially suited for evolving herbicide resistance. Resistance to herbicides that inhibit acetolactate synthase (ALS), photosystem II (PSII), protoporphyrinogen oxidase (PPO) and glyphosate has been observed, as well as multiple resistance stacked in populations. Herbicides that inhibit 4-hydroxyphenylpyruvate dioxygenase (HPPD; EC1.13.11.27) provide a solution with an alternative mode of action (MoA) to control *Amaranthus* weeds. Their broad-spectrum weed control and excellent crop tolerance are key factors to their integration into maize and other crop production systems. The evolution of HPPD resistance will increase the complexity of *Amaranthus* weed control. A better understanding of the spatial and temporal evolution of HPPD resistance in *Amaranthus* populations will contribute to select the best strategy to control these weeds and contain and delay as much as possible the development of resistance to the inhibitors of this new MoA. Case studies have been started in 2011 in three locations in Nebraska, Kansas, and Illinois and will be continued over 3 to 5 years. In each case, populations have been harvested starting from a central point and around it with increasing distances. Biotests were performed in the greenhouse using pre-emergence and post-emergence HPPD inhibitors. First biotest data will be reported. So far the major point to stress is that the resistance to HPPD inhibitors seems to remain localized to the central point(s) of the sampling areas. Moreover first examples of the metabolism of an HPPD inhibitor between a sensitive and a resistant *Amaranthus* biotype will be presented.

U.S. UNIVERSITY HERBICIDE EFFICACY STUDIES ANALYSIS: CORN AND SORGHUM YIELD WITH ATRAZINE VERSUS ATRAZINE ALTERNATIVES: 2006-2010. Richard S. Fawcett*; Fawcett Consulting, Huxley, IA (187)

Previously, 20 years of corn herbicide efficacy studies conducted by university weed scientists and published in the North Central Weed Science Society Research Report were analyzed to compare corn yields with treatments containing atrazine to treatments lacking atrazine but containing atrazine alternatives. All treatments had to control both broadleaf and grass species, be applied at label rates, and registered for use at the time of the analysis. For the 236 studies analyzed for the period, 1986-2005, corn yielded an average 5.7 bushels/acre higher or 5.1% higher with atrazine than with alternatives. The North Central Weed Science Society discontinued publishing the Research Report after 2005. Therefore, to investigate the potential yield benefits of atrazine for years after that date, herbicide efficacy studies were obtained directly from universities or from a Syngenta Crop Protection database summarizing studies conducted by universities. Unlike the 1986-2005 analysis, which involved only Corn Belt states, the new analysis covered 22 states in all major corn-growing regions of the U.S. A total of 449 qualifying studies containing 5,991 qualifying treatments were analyzed for the years 2006-2010. Corn yielded an average 4.9 bushels per acre or 3.3% higher with atrazine than with atrazine alternatives. The yield benefit with atrazine was greatest with no-till systems, with a yield increase of 8.1 bushels per acre or 6.7%, compared to 4.6 bushels per acre (3.1%), and 4.4 bushels per acre (2.7%) for conventional and reduced tillage, respectively. Thus, atrazine continues to provide a yield benefit similar to that provided over the previous 20 years, despite the introduction of new herbicide actives and technologies such as herbicide-resistant corn. In addition to analyzing corn studies, sorghum yield studies were also analyzed. A total of 12 qualifying studies containing 131 qualifying treatments were analyzed for the years 2006-2010. Sorghum yielded an average 5.7 bushels per acre or 6.4% higher with atrazine than with atrazine alternatives.

BURNDOWN AND PREEMERGENCE WEED CONTROL WITH RIMSULFURON AND MESOTRIONE. Helen A. Flanigan*[1], Kevin L. Hahn[2]; [1]DuPont, Greenwood, IN, [2]DuPont, Bloomington, IL (188)

In 2012 university and DuPont small plot, replicated field studies were conducted throughout the US corn growing regions to compare preemerge performance of a rimsulfuron + mesotrione herbicide blend, otherwise known as DuPont™ Instigate™ herbicide, to competitive standards. Instigate™ is a dry formulation, water dispersible granule formulated as 4.17% rimsulfuron + 41.67% mesotrione which may be applied preplant, preemergence or postemergence up through two collars. Tank mixed with glyphosate or paraquat, and/or atrazine or atrazine-containing products, Instigate™ provided cross-spectrum burndown at planting as well as residual control. In field trials from the north central region, Instigate™ plus atrazine-containing products gave good to excellent residual control of velvetleaf, common lambsquarters, waterhemp, redroot pigweed, palmer amaranth, common ragweed, PA smartweed, foxtails, barnyardgrass and large crabgrass. Residual control was equal to the competitive standards. Instigate™ received federal registration in the third quarter of this year.

ENLIST™ CORN TOLERANCE TO ENLIST™ DUO APPLIED FROM V3 THROUGH V7 GROWTH STAGES. Neil A. Spomer[1], David C. Ruen*[2], Bradley W. Hopkins[3], Kevin D. Johnson[4], Brian D. Olson[5]; [1]Dow AgroSciences, Brookings, SD, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Westerville, OH, [4]Dow AgroSciences, Danville, IL, [5]Dow AgroSciences, Geneva, NY (189)

Enlist™ corn contains the *aad-1* gene which provides tolerance to 2,4-D. The Enlist trait has been stacked with the SmartStax® traits enabling applications of 2,4-D plus glyphosate from planting through the V8 growth stage. Enlist Duo™ with Colex-D Technology™ is a proprietary premix of 2,4-D choline + glyphosate dimethylamine for use on Enlist crops. Application rate will range from 1092 to 2185 g ae/ha with 1640 g ae/ha being the most commonly recommended rate. Results from 2011 demonstrated excellent tolerance of Enlist corn to Enlist Duo applied as single or sequential post-emergence applications at V4, V7 or V4 followed by application at V7 at 2185 to 4370 g ae/ha. Twelve trials were initiated in 2012 to test Enlist corn tolerance to Enlist Duo applied at six application timings beginning at V3 corn growth stage. The experiment was designed as randomized complete block arranged in a split plot with application timing as the main plot effect and herbicide treatment as the subplot effect. Treatments were Enlist Duo at 1640, 2185 or 4370 g ae/ha applied at corn growth stages V3, V3+7 d, V3+10 d, V3+14 d, V3+17 d or V3+21 d. Applications were made with standard small plot CO_2-pressurized backpack sprayers at 15 gallons per acre spray volume using flat fan air induction spray tips to deliver a very coarse spray. Visual crop injury ratings were taken at 7 and 14 days after each application. Crop response for a given herbicide treatment differed slightly between application timings. Analysis of growing degree day trends, using temperature values prior to, or following application timing, did not correlate with crop response differences for application timing. Results of these trials demonstrate excellent Enlist corn tolerance to Enlist Duo over a wide range of application timings and environmental conditions. Results from 2012 align with previous research showing Enlist corn stacked with SmartStax will provide robust tolerance to Enlist Duo herbicide from early post through the V8 growth stage.

®™ Trademark of Dow AgroSciences LLC. Components of the Enlist Weed Control System have not yet received regulatory approvals; approvals are pending. The information presented here is not an offer for sale. Enlist Duo herbicide is not yet registered for sale or use as a component of the Enlist Weed Control System. Always read and follow label directions.

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WEED CONTROL PROGRAMS IN ENLIST™ CORN. Joe Armstrong*[1], Scott C. Ditmarsen[2], Fikru F. Haile[3], Jeff M. Ellis[4], Jonathan A. Huff[5], Eric F. Scherder[6]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Madison, WI, [3]Dow AgroSciences, Indianapolis, IN, [4]Dow AgroSciences, Smithville, MO, [5]Dow AgroSciences, Herrin, IL, [6]Dow AgroSciences, Huxley, IA (190)

Enlist™ corn has been extensively evaluated in field research trials since 2006. Enlist corn is anticipated to launch in 2013, subject to regulatory approvals. Enlist corn, stacked with SmartStax®, will have tolerance to both 2,4-D and glyphosate. 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 to provide crop yield protection and to provide additional modes of action to manage weed resistance. Field research trials were conducted in 2011 and 2012 to evaluate a system approach involving Enlist Duo, in conjunction with SureStart™ herbicide (acetochlor + clopyralid + flumetsulam). Weed control and crop tolerance studies were conducted utilizing weed management systems consisting of SureStart applied preemergence (PRE) followed by postemergence (POST) application of Enlist Duo to V4 to V5 corn, SureStart plus Enlist Duo applied early POST to V2 corn, or SureStart plus Enlist Duo applied POST to V4 corn. SureStart was applied at 1X and 2/3X of the full recommended rate for the soil type in 2011and 2012, respectively. The rate of Enlist Duo was 1640 g ae/ha. Weed control ratings were taken at 0, 14 and 28 days after the V4 to V5 application. Preemergence followed by POST, early POST only, or POST only treatments provided >90% control of ABUTH, AMARE, AMATA, AMBEL, AMBTR, CHEAL, IPOSS, SIDSP, and XANST species. Crop tolerance ratings were taken at 7 and 14 days after the V2 and V4 applications in 2012. 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 4 and 1% injury at 7 and 14 days after application. Applications of SureStart + Enlist Duo at the V4 growth stage resulted in 9 and 2% injury at 7 and 14 days after application, respectively. These studies 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. Residual herbicides provide an effective means to prevent yield loss due to early season weed competition and bring additional modes of action to the weed control system as a component of weed resistance management best practices.

™Enlist, Enlist Duo, and SureStart are trademarks of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Components of the Enlist Weed Control System have not yet received regulatory approvals; approvals are pending. The information presented here is not an offer for sale. Enlist Duo herbicide is not yet registered for sale or use as a component of the Enlist Weed Control System. Always read and follow label directions.

HISTORICAL VIEW OF INTRODUCED PLANTS THAT HAVE BECOME INVASIVE. William W. Witt*; University of Kentucky, Princeton, KY (194)

Plant introductions to supposedly enhance human endeavors in the United States have occurred for over 200 years and continue today. The Weed Science community is well aware of many introductions (johnsongrass, kudzu, kochia, multiflora rose, musk thistle) that continue to be serious problems in grain crops, pastures, and road ways. Invasive weeds are one of the "hot topics" over the past decade and resulted in concerted efforts by persons not in our Weed Science community to control several species. I interact frequently with such groups and their passion for control is great but they rarely see johnsongrass as invasive although it continues to be a major weed in Kentucky. Other examples of this problem occur in all states. Plants were introduced to serve as forages (johnsongrass, Old World Bluestems, bermudagrass, kudzu), fiber (velvetleaf), windbreaks (multiflora rose), wildlife food source (bush honeysuckles, autumn olive), and aquaria plants (hydrilla). The list of ornamentals is lengthy: corn cockle, Japanese knotweed, jimsonweed, lantana, musk thistle, salt cedar, tree of heaven, water hyacinth, Chinese silver grass, and cogongrass). Biofuel plants are of great interest currently to augment our dependence on oil and coal as energy sources. However, there is a need for more information on the biology and ecology of these species. What do we know about these plants being evaluated for their energy production? What is the potential for some of these species to become major weed problems in the future? Weed scientists need to be concerned about this potential and get actively involved in making our concerns known to the biofuel industry and various governmental agencies.

ROLE OF *MISCANTHUS* SPP. IN THE BIOFUEL INDUSTRY AND THEIR POTENTIAL INVASIVENESS. Emily Heaton*[1], Allison Snow[2], Miriti Maria[2]; [1]Iowa State University, Ames, IA, [2]Ohio State University, Columbus, OH (195)

With the introduction of transgenic perennial grasses as biofuel cultivars, data on the extent and consequences of gene flow are needed for risk assessment. Miscanthus species, native to Asia but now common as ornamentals in the USA, are being developed by both commercial and public interests into cultivars with improved agronomic traits; both seeded and transgenic lines were field-tested in 2011. In the US, there is little information about the ecology and distribution of free-living populations of Miscanthus. Biofuel cultivars may become naturalized and could hybridize with feral and ornamental *M. sinensis* and *M. sacchariflorus*. For example, new cultivars that are 4x may hybridize with 4x *M. sacchariflorus*, which has become naturalized in the upper Midwest. Transgenic forms of *M. sinensis*, a 2x species that has become invasive in many eastern states, are also in development. This presentation will first set forth the context for evaluating Miscanthus in the US, then will describe our progress in addressing information gaps related to gene flow characterization and biotype fitness. Focusing on a range of feral and improved populations in Ohio and Iowa, we assess Miscanthus using field surveys and common garden experiments, along with population projection models that integrate key life-cycle data. Our findings will be useful for establishing isolation distances for field trials, managing volunteers from field trials, and evaluating larger-scale ecological consequences, if any, of gene flow from biofuel crops to feral populations.

VARIOUS FORMULATIONS AND ADJUVANTS INFLUENCE SPRAY DROPLET SPECTRA. Lillian C. Magidow*, Gregory K. Dahl, Stephanie Wedryk, Eric P. Spandl, Joe V. Gednalske; Winfield Solutions, St. Paul, MN (200)

Droplet size analysis of agricultural sprays using laser diffraction will be a critical part of verifying drift reduction technologies (DRT) for compliance with drift regulations. Previous work has focused on factors including spray conditions, nozzle selection, and drift modifying adjuvants. Due to technical limitations, few laboratories have been able to test active pesticide formulations. Some test standards propose the use of 'blank' formulations (without active pesticide molecules) or water alone to simulate the droplet spectrum of complex tank mixtures. This study evaluated the droplet spectra variety of agricultural tank mixtures, including active pesticide formulations, and nozzles using a Sympatec HELOS-KR laser diffraction particle size sensor in a fully enclosed low speed wind tunnel (air flow 8 ± 0.5 mph concurrent with the spray). The test instrument was designed and operated in accordance with ASAE S572.1 and ASTM E2798-11 and E1260-03 standard methods. Active formulations were delivered using field-appropriate rates, nozzles, and pressures, and the full width of the spray pattern was sampled. The effect of formulation and nozzle on various spray parameters was measured. These parameters included the cumulative percent of spray volume comprising droplets smaller than 105 µm, or "driftable fines," and the percent change in this quantity relative to a standard. Active formulations significantly altered particle size distributions within each nozzle. "Blank" mixtures and water did not simulate the particle size distribution of several common tank mixtures. Nozzle classification relative to manufacturer classifications varied by tank mixture, as did the resulting % driftable fines. Classification of nozzles and other products and application techniques as DRT should take into account the alteration of spray characteristics due to tank mixture.

NONIONIC SURFACTANT ADJUVANT WITH OPTIMIZED PHYSICAL AND BIOLOGICAL PROPERTIES FOR HERBICIDE TANK MIXTURES. Gregory J. Lindner*[1], Kevin Penfield[1], Bryan G. Young[2]; [1]Croda Inc, New Castle, DE, [2]Southern Illinois University, Carbondale, IL (201)

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. Physical performance data confirms low contact angle signifying desirable wetting properties and spreading coefficient, low surface tension indicating effective surfactant performance, low viscosity at a range of temperatures suggesting good bulk handling without use of alcohols or glycols, solubility in a selection of oils across a range of temperatures, and good to excellent dilution performance either "as is" or as an oil adjuvant emulsifier.In mixtures with glyphosate, i t did not significantly increase the volume of driftable fine droplets and unlike other NIS adjuvants tested it effectively reduced the volume fraction of smaller droplets in most nozzles tested (consistent with the internal standard used as a positive control). 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). The adjuvant 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.

EFFECT OF DROPLET SIZE ON WEED CONTROL WITH DICAMBA AND GLYPHOSATE TANK-MIXTURES APPLIED WITH COMMERCIAL SPRAYERS. Christopher D. Kamienski*[1], Brian Olson[2], Joe Sandbrink[3], Kirk Remund[4], Jeff N. Travers[3]; [1]Monsanto Company, Washington, IL, [2]Monsanto Company, Colby, IL, [3]Monsanto, St. Louis, MO, [4]Monsanto Company, St. Louis, MO (202)

Strategies to reduce off target movement of herbicides include the use of spray tips and drift reducing agents that reduce physical drift by altering droplet size, usually by creating larger droplets and/or minimizing fine spray droplets. However, larger spray droplets may have a negative effect on weed control if the droplet size does not allow for proper herbicide coverage, uptake and translocation. In 2012, field trials were conducted at 13 locations across the United States. Treatments included the following spray tips: TurboTeeJet® Wide Angle Flat Spray Tip (TT), AIXR TeeJet® Air Induction XR Flat Spray Tip (AIXR) and the Turbo TeeJet® Induction Flat Spray Tip (TTI). All spray solutions contained glyphosate (1120 g ae/ha), dicamba (560 g ae/ha) and Interlock (290 g ai/ha). Applications were made with sprayers equipped with spray booms ranging in size from 7.62 - 30.48 m. Sprayer travel speed ranged from 10.5 – 19.3 km/h, while operating pressure ranged from 207 – 345 kPa. The application volume was 94 – 187 L/ha. Treatments were applied postemergence (POST) to corn before the V5 growth stage or fallow fields with weed heights ranging from 10 – 50 cm. Weed control ratings were taken 7 to 10 days after treatment (DAT) and 16 to 23 DAT. Average weed control ratings for the final evaluation, across all species, locations, and rating dates was 96.9, 96.7, and 96.5% for the TT, AIXR, and TTI treatments, respectively. There were no significant differences across the three nozzles within individual weed species, which included velvetleaf (*Abutilon theophrasti*) Palmer amaranth (*Ameranthus palmeri*), waterhemp (*Amaranthus tuberculatus syn. rudis*), glyphosate-resistant (GR) waterhemp (*Amaranthus tuberculatus syn. rudis*), common ragweed (*Ambrosia artemisiifolia*), common lambsquarters (*Chenopodium album)*, kochia (*Kochia scoparia*), and large crabgrass (*Digitaria sanguinalis*). These results suggest that drift reducing nozzles should provide good weed control potential when applying dicamba plus glyphosate mixtures.

A COMPARISON OF DROPLET SPECTRA FROM 10 TYPES OF GROUND NOZZLES. Ryan S. Henry*[1], Annah Geyer[2], Lowel Sandell[3], Wesley C. Hoffmann[4], Bradley K. Fritz[4], William E. Bagley[5], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]USDA-ARS, College Station, TX, [5]Wilbur-Ellis, San Antonio, TX (205)

Pesticide applicators in the US are faced with several decisions to make before applying a pesticide. Spray droplet size is a critical factor influencing the drift potential and efficacy of a pesticide. Nozzle selection can directly affect the final spray quality, and growers have numerous choices of nozzle type and orifice size. Ten commonly used ground application nozzles were examined in a low speed wind tunnel using a laser diffraction system to measure droplet size. Both water and a glyphosate solution were tested to illustrate the impact that a nozzle can have on droplet size and spray quality. Inclusion of glyphosate in the spray solution decreased the spray droplets diameter and increased the percent of the spray volume less than 200 µm. This effect was greatest in the flat fan nozzles. Nozzles with an internal expansion chamber, pre-orifice plate, and/or air inclusion ports produced the largest droplets. Pressure had an effect on the spray quality and droplet size. Droplet size decreased as pressure increased with the exception of the small orifice TTI nozzles. This data highlights the importance of testing nozzles with solutions beyond water alone in order to accurately examine droplet size. Dissemination of this data to growers will aid in their decision making before applying pesticides.

WILL DUAL OUTLET VENTURI NOZZLES HAVE AN IMPACT ON WEED CONTROL? Robert E. Wolf*[1], Scott M. Bretthauer[2]; [1]Wolf Consulting & Research LLC, Mahomet, IL, [2]University of Illinois, Urbana, IL (206)

The objective of this study was to evaluate weed control efficacy and droplet size of dual outlet drift reduction nozzles and adjuvants for glyphosate-dicamba applications. Treatments included the following nozzles from Spraying Systems: Turbo TeeJet Induction (TTI11004) as a single outlet nozzle for standard comparison; Air Induction Turbo TwinJet (AITTJ60-11004); and AI3070 11004; from Greenleaf, the TurboDrop Asymmetric Dual Fan (TADF11004); and from Hypro, the GAT 11004. All were tested at 331 kPa (48 psi). Applications were made with an ATV mounted CO_2 sprayer operated at 21 km/h (13 mph) and a spray volume of 94 L/ha (10 GPA). All spray solutions contained glyphosate at 840 g ae/ha (0.75 lb ae/A) of Roundup® WeatherMax, dicamba (420 g ae/ha (0.375 lb ae/A) of Clarity®), and liquid AMS (N-PaK® at 2.5% v/v). All nozzles were tested with and without Array® at 4.1 kg per 379 L (9 lbs per 100 gal) and Interlock® at 292 ml/ha (4 fl oz/A). For the Array® mix the AMS was not included. A soybean field was sprayed with the treatments. The droplet size spectrums of all nozzle and drift reduction adjuvant combinations were measured using a Sympatec Helos laser diffraction droplet sizing system in a low speed wind tunnel. Average control among all species and nozzle treatments was 95.3%. When averaged across all nozzle types, the treatments including Roundup® WeatherMax, Clarity®, and AMS with no deposition aids had control ranging from a high of 99.0% for cocklebur and common ragweed to a low of 84.3% for morningglory. All grass species were controlled at 98.5%, with the Amaranthus species at 95.2%, and velvetleaf at 95.1%. When Interlock® was added to the tank mix, the highest control was with cocklebur at 99%, next was velvetleaf at 97.8%, followed by the grass species at 97.6%, common ragweed at 94%, and morningglory had the least control at 79.5%. When Array® was added to the tank mix, the highest control was for cocklebur at 99%, followed by velvetleaf at 96.9%, grass species at 96.8%, common ragweed at 97.4%, Amaranthus species at 94.5%, and the least was with morningglory at 87.5%. Measuring across all weed species and nozzle treatments, the Array® treatments averaged highest in control at 95.4%, with chemical only next at 95.2%, and the Interlock® treatments at 93.9%. Comparing the nozzle types across all weed species for the chemical only treatments resulted in the TTI with the highest control at 97.4%. Next were the AI30/70 and the GAT at 95.3% each, followed by the TADF at 95.2% and the AITTJ-60 at 92.6%. When adding Interlock® to the tank mix the results for weed control were: the AITTJ-60 at 94.3%, AI30/70 at 93.8%, the TADF, GAT, and TTI were lowest and the same at 93.7%. When changing the tank mix to include Array®, the TTI was the best at 97.8%, with the GAT next at 97%, followed by the AITTJ-60 at 96.9%, the TADF at 96.3%, and the AI30/70 at 95.4%.

APPLICATION TECHNOLOGY UPDATE...EQUIPMENT, NOZZLES, AND MORE. Robert E. Wolf*; Wolf Consulting & Research LLC, Mahomet, IL (207)

Modern commercial application systems today are bigger, faster, and can cost nearly $400,000. With this much invested in a single sprayer, the need to cover many acres is very important to those who own them. Part of the increase in value for these systems is that the latest sprayer technology involves the incorporation of various electronic controls designed to improve the efficiency of the application process. GPS technology is allowing for the incorporation of various components including auto-steer, automatic boom height control, automatic boom swath control, and field mapping for prescription/variable rate applications. There is an increased interest in nozzles designed with flexible orifices to deliver variable rates to be used to make variable rate applications. Pulse width modulation is being further refined to increase application efficiency for both droplet size control and more uniform applications along the boom and across the field. A flow back control valve designed to reduce spray loss when turning off the spray boom either manually or automatically is now available to improve efficiency and to reduce the incidence of spraying in non-spray areas of the field. Other technologies are being incorporated into the sprayers to assist in more efficient cleanout procedures.

FORTY YEARS OF SPRAYER EVALUATIONS. Robert N. Klein*; University of Nebraska, North Platte, NE (208)

In the early 70s, we started spraying winter wheat stubble fields shortly after winter wheat harvest. This was in preparation to planting corn or grain sorghum the next spring or even winter wheat the next fall. Prior to this, the spraying was to control weeds in crops or pasture which were also green so if you missed a few weeds, control could still be rated good or even excellent. Also, any weeds not controlled in the winter wheat stubble did very well because they did not have any crop competition. They also produced seed which made weed control difficult in the following crop. The uncontrolled weeds used soil water and could even result in crop failure the next year. Application errors have been blamed for 85 to 90% of herbicide failures. A Nebraska study found that only 30% of the cooperators were applying herbicides within 5% of their intended application rate. Herbicide failures were associated with selection of nozzle type, mismatched, plugged or badly worn nozzles, nozzle spacing, nozzle pressure, uneven pressure in lines, nozzle height and nozzle angle. Speed of the sprayer, wind speed, mixing and calibration errors are among other factors that contributed to herbicide failures. Checking the nozzle output has been an effective method to identify many of the quantity related problems. Spray tables were used to determine the quality of the spray pattern. Still performance problems existed even when the sprayer was checked for quantity of spray solution and quality of spray pattern. One could blame the herbicide but demonstration tests have shown the herbicides to be effective. Let us take a look first at how most herbicide tests are performed. Conditions are usually as follows: Sprayer speed at 1.8 to 2.0 mph, and wind usually less than 5 mph in order to reduce drift on adjoining plots. These conditions are not very typical of field applications. The spray table could be used in the wind, but it would not simulate field conditions where the sprayer speed and the effects of wind and speed of sprayer are combined. Good herbicide performance requires even distribution of the herbicide. Therefore, equipment was needed to be able to analyze spray patterns under field conditions. Equipment was assembled at the University of Nebraska West Central Research and Extension Center located at North Platte to analyze spray patterns under field conditions. Rhodamine dye solution was added to the sprayer tank. A track was used to hold a paper tape, similar to adding machine tape. The sprayer was then run over the tape at the same speed and pressure as in field spraying. The ends of the paper tape were covered so they were not contaminated with the spray solution containing the dye, as a zero referencing point is needed for the fluorometer. The fluorometer was interfaced with a computer and flatbed chart recorder. Clinics were held to analyze the quantity of spray as well as the quality of the spray pattern using the computer analyzation equipment. Recommendations were made to improve the spray quantity and quality of the spray pattern. The last performance improvement included the use of a laser to determine spray particle sizes. This included how nozzle type, pressure, pesticides, and additives affect the spray particle size.

DEVELOPMENT AND EVALUATION OF A CRYOGENIC SPRAY SYSTEM FOR WEED CONTROL. Matthew A. Cutulle*[1], Gregory R. Armel[2], James Brosnan[1], Jose J. Vargas[3], William Hart[1], Dean A. Kopsell[3]; [1]University of Tennessee, Knoxville, TN, [2]BASF, Research Triangel Park, NC, [3]The University of Tennessee, Knoxville, TN (209)

A cryogenic weed control system was developed to improve weed control in row crops without the input of synthetic or organic pesticides. The cryogenic system applies liquid nitrogen to target weeds through a modified sprayer and then crushes foliage with a ballasted mechanical roller. The cryogenic system constructed for field use was comprised of a liquid nitrogen tank, a customized stainless steel vacuum-sealed hose, a brass flat fan spray nozzle, a polyurethane insulated spray hood and a mechanical compaction device consisting of a smooth roller with traction spikes. Greenhouse studies were performed at the University of Tennessee in 2009 to validate the biological impact of directed liquid nitrogen supplemented and mechanical pressure on large crabgrass (*Digitaria sanguinalis*). The greenhouse studies were conducted as a randomized complete block with 3 replications. Plants were maintained in pine bark culture and treated with liquid nitrogen and a hand held metal compaction device. Percent injury was recorded 7 days after treatment (DAT]). Results of the greenhouse studies indicated that combining mechanical pressure with liquid nitrogen increased crabgrass injury relative to treating the plants with only liquid nitrogen. Field studies were performed to determine the effects of liquid nitrogen volume, spray nozzle height, and mechanical roller pressure on pitted morningglory (*Ipomoea lacunose*) control in 2009 and 2010. The field trials were conducted as a randomized complete block with 3 replications at the East Tennessee Agricultural Research and Education Center (Knoxville, TN) and repeated at an adjacent field location. Plant height measurements and percent control ratings were taken 7 DAT. Morningglory was most effectively controlled with 9,360 L/ha of liquid nitrogen applied with a nozzle raised 30 cm above the soil surface, followed by 41 kPa of pressure with the mechanical roller. This cryogenic system provides a successful prototype to follow for future designs utilizing liquid nitrogen for weed control.

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U.S. UNIVERSITY HERBICIDE EFFICACY STUDIES ANALYSIS: CORN AND SORGHUM YIELD WITH ATRAZINE VERSUS ATRAZINE ALTERNATIVES: 2006-2010.

Richard S. Fawcett, Fawcett Consulting, Huxley, IA 50124.

Abstract. Previously, 20 years of corn herbicide efficacy studies conducted by university weed scientists and published in the North Central Weed Science Society Research Report were analyzed to compare corn yields with treatments containing atrazine to treatments lacking atrazine but containing atrazine alternatives. All treatments had to control both broadleaf and grass species, be applied at label rates, and registered for use at the time of the analysis. For the 236 studies which met the criteria for use in the analysis for the period, 1986-2005, corn yielded an average 5.7 bushels/acre (5.1%) higher when treated with atrazine than with alternative herbicides.

The North Central Weed Science Society discontinued publishing the Research Report after 2005. Since 2005 herbicide efficacy studies were obtained directly from universities or from a Syngenta Crop Protection database summarizing studies conducted by universities. Unlike the 1986-2005 analysis, which involved only Corn Belt states, the new analysis covered 22 states in all major corn-growing regions of the U.S. A total of 449 qualifying studies containing 5,991 qualifying treatments were analyzed for the years 2006-2010. Corn yielded an average 4.9 bushels per acre (3.3%) higher when treated with atrazine than with alternative herbicides. The yield benefit with atrazine was greatest in no-till systems, with an increase of 8.1 bushels per acre (6.7%), compared to 4.6 bushels per acre (3.1%), and 4.4 bushels per acre (2.7%) for conventional and reduced tillage, respectively. Thus, atrazine continues to provide yield benefits despite the introduction of new herbicide active ingredients and technologies such as herbicide-resistant corn. In addition to analyzing corn yields, 12 sorghum yield studies containing 131 treatments were found to meet the criteria for analysis. For the years 2006-2010 sorghum yielded an average of 5.7 bushels per acre (6.4%) higher when treated with atrazine than with alternative herbicides.

Introduction

In 1996 and in 2006, herbicide efficacy studies reporting corn yields published in the North Central Weed Science Society Research Report, a journal for annual progress reports published by the North Central Weed Science Society (NCWSS) representing states in the Corn Belt Region of the U.S., were analyzed to calculate average corn yields for herbicide treatments either containing atrazine or not containing atrazine. States represented in these analyses were Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, South Dakota, and Wisconsin. To prevent unequal comparisons, studies and treatments had to meet numerous conservative selection criteria to be included in the analysis. Treatments had to control both broadleaf and grass weeds, used at label rates, and active ingredients had to be registered for use at the time of the analysis (they could be experimental at the time of the study). Full details of methods used and results for analysis of 20 years of studies are available in the report, Twenty Years of University Corn Yield Data: With and Without Atrazine, published in the Proceedings of the 2008 NCWSS Conference available at the NCWSS website: www.ncwss.org/. For the 20-year period (1986-2005), 236 qualifying studies were identified, with a total of 5,871 qualifying treatments. From 1986 through 1995, corn yielded an average 6.3 bushels/acre (5.9%) higher when treated with atrazine than with alternative herbicides. From 1996 through 2005, corn yielded an average 5.4 bushels/acre (4.6%) higher when treated with atrazine. Yields continued to be higher in corn treated with atrazine than in corn treated with alternative products even as many new active ingredients and new technologies such as herbicide-tolerant corn hybrids were introduced.

2006-2010 Yield Analysis

The NCWSS terminated publication of the Research Report in 2006. Since 2005, an alternative method of obtaining studies was devised. University weed science websites were visited to obtain appropriate studies when available. To obtain studies not available on websites, a Syngenta Crop Protection Database was utilized. This database contains herbicide efficacy studies conducted by university weed scientists and submitted to Syngenta. A total of 449 qualifying studies were found and are listed in the Studies Cited section. The 22 states from which qualifying studies were found are: Arkansas, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New York, North Carolina, Ohio, Pennsylvania, South Dakota, Tennessee, Texas and Wisconsin.

In addition to analyzing corn herbicide efficacy studies, sorghum studies were also evaluated. Atrazine is one of the few herbicides registered for use on sorghum; therefore more than 80% of the studies did not meet study selection criteria of at least two non-atrazine treatments. Twelve qualifying studies were found and are listed in the Studies Cited section. The five states with qualifying studies were Arkansas, Kansas, Nebraska, South Dakota and Texas.

The source of each study is listed after the citation, with (W) denoting university website and (S) denoting Syngenta database. University websites containing studies are:

University of Illinois: http://weeds.cropsci.illinois.edu/field%20reports/default.htm
Southern Illinois University: http://www.siu-weeds.com/research/index.html
Western Illinois University: www.wiu.edu/ag/weedtrials/
Iowa State University: www.weeds.iastate.edu/reference

Kansas State University:
http://www.agronomy.k-state.edu/extension/DesktopDefault.aspx?tabid=73
Michigan State University: http://msuweeds.com/research/
University of Minnesota: http://appliedweeds.cfans.umn.edu/research.html
University of Missouri: http://weedscience.missouri.edu/weedtrials/index.cfm
University of Nebraska: http://weedscience.unl.edu/research.cfm
Ohio State University: http://agcrops.osu.edu/specialists/weeds/field-research
Penn State University: http://extension.psu.edu/weeds/research
Purdue University: www.btny.purdue.edu/weedscience/resreport/BJ2005/default.htm
South Dakota State University:
http://plantsci.sdstate.edu/weeds/page.cfm?page=crop_search

The conservative selection criteria for studies and treatments in the 2006–2010 analysis were identical to those used in the two previous studies.

Corn yield results from analysis of studies conducted between the years 2006 and 2010 are presented in Table 1. Evaluation of the 5,991 qualifying treatments in 449 studies conducted by 24 U.S. university researchers at 74 experiment stations and sites used in this analysis, showed the average corn yield increase when treated with atrazine was 4.9 bushels per acre (3.3%). Sorghum yield results from analysis of studies conducted between years 2006 and 2010 are presented in Table 2. Evaluation of the 131 qualifying treatments in 12 studies conducted by five U.S. university researchers showed the average sorghum yield increase when treated with atrazine was 5.7 bushels per acre (6.4%). Corn yields continued to be higher when treated with atrazine than when treated with alternative herbicides, despite the introduction of new herbicide actives and technologies such as herbicide-tolerant corn.

The type of tillage system used in each corn study was obtained, and each study was categorized as either conventional (a combination of tillage tools leaving little surface crop residue), reduced (a system leaving about 30% or more surface crop residue) or no-till (no soil disturbance other than that caused by the planter or fertilizer application) (Table 1). The average yield increase with atrazine was 4.6 bushels per acre (3.1%), 4.4 bushels per acre (2.7%), and 8.1 bushels per acre (6.7%) for conventional tillage, reduced tillage and no-till, respectively. Thus, atrazine provides greater yield benefit in no-tillage systems.

Atrazine improves weed control compared to that of many alternative herbicides by controlling a very broad spectrum of broadleaf weeds and grasses, many of which are species not well-controlled by alternative products. Atrazine is also an important tool in weed resistance management, providing an alternative mode of action to herbicides used in herbicide-tolerant crops. Most of the studies analyzed involved the use of herbicide-tolerant corn (usually glyphosate-tolerant and less often glufosinate-tolerant). Weed scientists universally recommend using multiple herbicide modes of action either in combination or rotation to slow the development of weed resistance. Atrazine provides the alternative mode of action to glyphosate and glufosinate and thus continues to be used with these herbicide-tolerant corn systems, managing weed resistance as well as increasing yields.

Products used in 2010 corn studies either in treatments with or without atrazine are listed in Table 3, with active ingredients used with and without atrazine in Table 4. Only products and active ingredients used in at least 5 treatments (about 1%) are listed. Glyphosate-containing products were the most frequently used products with 78.8% of atrazine-containing treatments and 80.1% of non-atrazine treatments containing glyphosate (Table 4). Thiencarbazone-methyl (contained in Corvus and Capreno) and isoxaflutole (contained in Balance Flex and Corvus) were the most frequently used alternative herbicides, used on 21.4% and 20.8% of non-atrazine treatments, respectively. Important to note is that frequency of treatment inclusion in university trials will not necessarily resemble percent market share of products. In any year, the newest registered or experimental products will be evaluated most frequently due to interest of manufacturers and researchers.

Table 5 lists average numbers of active ingredients and application trips, and atrazine active rates for corn treatments in 1986, 2001 and 2010. Data for 1986 and 2001 are from the previous compilation of data from the NCWSS Research Report, and as such represent only states in the North Central region. Data for 2010 come from the present analysis and represent corn growing states in all regions.

Number of application trips did not vary greatly between treatments containing or lacking atrazine. Treatments containing atrazine averaged about 0.5 additional active ingredients. Additional active ingredients in atrazine-containing treatments is explained in part by the fact that no atrazine-alone treatments would qualify for inclusion in the analysis (and were almost never found in studies) due to lack of broad spectrum weed control. In contrast, glyphosate alone (usually as a split treatment) was a common single active ingredient treatment qualifying for inclusion due to broad spectrum weed control, thus reducing the average number of active ingredients included in non-atrazine treatments.

For treatments containing atrazine, application trips were 1.39, 1.53, and 1.55 for 1986, 2001 and 2010, respectively, showing a small increase over the years. The non-atrazine treatments had 1.45, 1.61 and 1.57 trips for 1986, 2001 and 2010 respectively. The average number of active ingredients in atrazine-containing treatments was 2.59, 3.32 and 3.63 for 1986, 2001 and 2010, respectively, compared to 2.09, 2.64 and 3.07 for non-atrazine treatments. Thus, numbers of active ingredients per treatment increased throughout the period. Average atrazine rates decreased over the period, from 1.17 lb a.i./acre in 1986, to 0.88 lb a.i./acre in 2001, to 0.83 lb a.i./acre in 2010. There were differences between states and regions in atrazine rates. For example, in Arkansas in 2010, the average atrazine rate used was 1.39 lb a.i./acre. The average rate in Iowa that year was 0.62 lb a.i./acre.

Statistical Analysis

Figure 1 shows the distribution of corn yields as a percent difference for yields with atrazine versus yields without atrazine. The data are not normally distributed, being skewed to the right. The mean percentage yield increase with atrazine for the 2006-2010 period was 3.30% (Table 6). As a parametric test may not be considered appropriate due to non-normal distribution of data, data were analyzed both by t-test and Wilcoxon Signed-Rank test. Both tests result in highly significant probabilities that the percent increase in yield with atrazine is greater than 0.0. Both tests result in significant probabilities that the increase in yield is greater than 1.75%. The result of the t-test is significant, while the Wilcoxon Signed-Rank test is not significant that the percent increase in yield is greater than 2.0%.

In Table 6, mean corn yield increases with atrazine are considered for different tillage types. The mean yield increase with atrazine for no-till was greatest at 6.73%, followed by conventional tillage at 3.12% and reduced tillage at a 2.7% increase. All observed yield increases are significant based on the analyses shown in Table 6. Sorghum yields with atrazine had a mean increase of 6.42% compared to yields with alternative products (Table 6). Both Wilcoxin Signed-Rank and t-tests result in significant probabilities that the percent yield increase with atrazine is greater than 2.0%.

Special Studies

Special studies designed specifically to investigate the benefit of adding atrazine to alternative broadleaf-controlling herbicide actives have shown even greater yield benefits than the routine herbicide efficacy studies comprising the bulk of studies in this analysis. For example, the University of Minnesota has conducted “Atrazine BMP Rate” studies investigating the specific benefit of adding the relatively low rate of 0.5 lb/A atrazine to other broadleaf herbicide alternatives. Table 7 contains a summary of three site-years of data from these studies. Considering the average corn yields from the three site-years (from two locations), the benefit from adding one-half pound of atrazine to Callisto, to Hornet and to Clarity was 27.6 bu/A , 30.3 bu/A , and 20.7 bu/A respectively. This large yield benefit illustrates why atrazine is so routinely included in herbicide treatments, either as tank mixtures made by the applicator or prepackaged combinations sold by herbicide manufacturers. Because atrazine can be applied both prior to or after corn emergence and has both preemergence and postemergence activity, it has utility in nearly all herbicide programs. As described in the NCWSS paper (2008 NCWSS Proc. 63:137) use of atrazine with other actives has steadily increased in recent years as shortcomings of new actives are realized by weed scientists. By 2004, 80% of all treatments evaluated in university weed control trials contained atrazine. As with the NCWSS analysis, in the current analysis numerous studies did not meet the criteria of including at least two non-atrazine treatments occurring in the study.

Atrazine Cost vs. Alternatives

In addition to being highly efficacious on many weeds found in corn and sorghum, and being highly safe to these crops, atrazine is one of the most economical herbicides. Table 8 presents average per acre costs of atrazine and that of 25 other herbicides labeled to control certain broadleaf weeds in corn. The average cost of atrazine at the common use rate of 1.0 pound per acre is $3 per acre. The average cost of the alternative herbicides at common labeled use rates is $14.75 per acre. Thus, atrazine costs $11.75 per acre less than the average cost of alternatives. The only herbicide alternative costing less than atrazine is 2,4-D, a herbicide limited in use due to the fact that it can be used only as a postemergence treatment and due to corn injury and risk of drift.

Conclusions

The analysis of 449 studies with 5,991 treatments conducted by university researchers in 22 states showed that use of atrazine increased corn yield by an average 4.9 bushels/acre (3.3%), compared to comparable treatments lacking atrazine. Unlike the previous analyses which involved only Corn Belt states, the current analysis covered 22 states, demonstrating that the yield advantage from atrazine occurs throughout corn growing areas of the U.S. The analysis of 12 studies with 131 qualifying treatments conducted by university researchers in five states showed that use of atrazine increased sorghum yield by an average 5.7 bushels per acre or 6.4% compared to comparable treatments lacking atrazine.

Despite the registration of many new herbicide active ingredients and introduction of new technologies such as herbicide-tolerant corn over recent years, atrazine continues to increase yields by improving weed control while being highly safe for use in corn. Indeed, atrazine is usually used with new active ingredients either in tank mixes or prepackaged herbicide mixtures. As weed spectrum weaknesses of new active ingredients become apparent, university weed scientists and herbicide manufacturers increasingly recommend adding atrazine to weed control programs for better efficacy against a broad spectrum of weed species. Currently more than 90 prepackaged mixes of products containing atrazine are sold by 23 different companies. Seventeen different active ingredients are represented in these package mixes. Often, relatively low rates of atrazine can significantly improve weed control and yields. In three University of Minnesota studies, one-half pound per acre of atrazine increased yields by an average 26.2 bushels per acre when added to three different alternative herbicides.

There are few alternatives to atrazine registered for use in sorghum, illustrated by the fact that in nearly 80% of all university sorghum herbicide efficacy studies, atrazine was contained in all treatments, making the study not useful in this analysis.

In addition to increasing corn yields due to superior efficacy, atrazine remains one of the lowest cost herbicides, costing an average $11.75 per acre less than corn herbicide alternatives.

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Table 1. U.S. corn yields with and without atrazine, 2006-2010.

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	Tillage	# Trts.	Avg. Yield (bu/A)	# Trts.	Avg. Yield (bu/A)	(bu/A)	(%)
				2006				
6-AR-1	AR	Conven.	4	204.3	9	199.3	-5.0	-2.4
6-AR-2	AR	Conven.	2	210.2	12	209.0	-1.2	-0.6
6-AR-3	AR	Conven.	2	208.9	6	209.8	+0.9	+0.4
6-AR-4	AR	Conven.	4	210.5	9	208.1	-2.4	-1.1
6-AR-5	AR	Conven.	4	228.9	3	219.9	-9.0	-3.9
6-DE-1	DE	Conven.	4	158.3	3	170.4	+12.1	+7.6
6-DE-2	DE	Conven.	2	181.0	5	197.0	+16.0	+8.8
6-DE-3	DE	Conven.	10	181.3	3	181.2	-0.1	-0.1
6-DE-4	DE	Conven.	6	147.7	2	162.3	+14.6	+9.9
6-IA-1	IA	No-Till	2	158.0	4	171.3	+13.3	+8.4
6-IA-2	IA	Reduced	2	206.0	11	214.5	+8.5	+4.1
6-IA-3	IA	Reduced	5	217.6	7	222.9	+5.3	+2.4
6-IA-4	IA	Reduced	8	222.3	3	228.3	+6.0	+2.7
6-IA-5	IA	Reduced	4	229.5	10	229.8	+0.3	+0.1
6-IL-1	IL	Reduced	3	155.1	9	185.6	+30.5	+19.7
6-IL-2	IL	Reduced	3	214.0	16	218.6	+4.6	+2.1
6-IL-3	IL	Reduced	2	86.7	12	109.9	+23.2	+26.8
6-IL-4	IL	Reduced	2	167.5	12	177.5	+10.0	+6.0
6-IL-5	IL	No-Till	5	150.4	4	153.0	+2.6	+1.7
6-IL-6	IL	Reduced	2	194.0	8	200.6	+6.6	+3.4
6-IL-7	IL	Reduced	4	129.3	15	132.6	+3.3	+2.6
6-IL-8	IL	Reduced	4	150.1	17	162.8	+12.7	+8.5
6-IL-9	IL	Reduced	2	167.5	12	177.5	+10.0	+6.0
6-KS-1	KS	Conven.	5	27.4	11	29.0	+1.6	+5.8
6-KY-1	KY	No-Till	2	201.4	7	223.3	+21.9	+10.9
6-LA-1	LA	Conven.	2	119.7	3	141.0	+21.3	+17.8
6-MD-1	MD	Conven.	4	205.5	8	204.6	-0.9	-0.4
6-MD-2	MD	Conven.	4	202.8	3	204.6	+1.8	+0.9
6-MD-3	MD	Conven.	6	154.7	4	163.4	+8.7	+5.6
6-MN-1	MN	Conven.	6	181.0	10	179.1	-1.9	-1.0
6-MN-2	MN	Conven.	6	214.3	10	214.6	+0.3	+0.1
6-MN-3	MN	Conven.	6	167.5	10	179.2	+11.7	+7.0
6-MN-4	MN	Conven.	6	197.7	10	197.8	+0.1	+0.1
6-MN-5	MN	Conven.	6	212.7	10	210.0	-2.7	-1.3
6-MN-6	MN	Conven.	6	168.0	10	155.8	-12.2	-7.3
6-MN-7	MN	Conven.	7	134.7	11	154.5	+19.8	+14.7
6-MN-8	MN	Conven.	6	196.8	13	195.7	-1.1	-0.6

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	**State**	**Tillage**	**# Trts.**	**Avg. Yield**	**# Trts.**	**Avg. Yield**		
				(bu/A)		**(bu/A)**	**(bu/A)**	**(%)**
6-MN-9	MN	Conven.	6	189.0	3	196.0	+7.0	+3.7
6-MN-10	MN	Conven.	4	166.5	14	178.1	+11.6	+7.0
6-MO-1	MO	Conven.	4	127.1	9	127.9	+0.8	+0.7
6-MO-2	MO	Conven.	7	163.8	15	171.4	+7.6	+4.6
6-MO-3	MO	No-Till	2	119.4	3	118.5	-0.9	-0.8
6-MO-4	MO	Conven.	5	110.5	9	114.2	+3.7	+3.3
6-MO-5	MO	Conven.	5	111.9	12	122.5	+10.6	+9.5
6-MO-6	MO	Conven.	5	180.6	5	182.7	+2.1	+1.2
6-MS-1	MS	No-Till	5	138.0	6	141.7	+3.7	+2.7
6-MS-2	MS	No-Till	5	54.1	6	56.5	+2.4	+4.4
6-MS-3	MS	No-Till	4	119.0	8	121.7	+2.7	+2.3
6-NY-1	NY	Reduced	3	176.1	11	182.6	+6.5	+3.7
6-OH-1	OH	Conven.	3	197.2	3	226.1	+28.9	+14.7
6-OH-2	OH	Conven.	6	157.3	7	223.4	+66.1	+42.0
6-OH-3	OH	Conven.	4	230.9	9	240.7	+9.8	+4.2
6-OH-4	OH	No-Till	3	176.9	4	186.9	+10.0	+5.7
6-SD-1	SD	Conven.	9	167.3	13	169.1	+1.8	+1.1
6-SD-2	SD	Conven.	10	183.1	11	186.5	+3.4	+1.9
6-TN-1	TN	No-Till	4	89.5	3	100.6	+11.1	+12.4
6-TN-2	TN	No-Till	4	147.7	8	154.5	+6.8	+4.6
6-TN-3	TN	No-Till	3	126.6	3	141.0	+14.4	+11.4
6-TX-1	TX	Conven.	4	108.8	4	102.6	-6.2	-5.7
6-WI-1	WI	Conven.	3	160.7	8	196.0	+35.3	+22.0
2007								
7-AR-1	AR	Conven.	3	165.0	3	167.9	+2.9	+1.8
7-AR-2	AR	Conven.	4	169.2	2	173.3	+4.1	+2.4
7-AR-3	AR	Conven.	7	182.5	14	181.5	-1.0	-0.5
7-AR-4	AR	Conven.	4	180.8	10	178.6	-2.2	-1.2
7-AR-5	AR	Conven.	3	163.0	7	159.0	-4.0	-2.5
7-AR-6	AR	Conven.	7	230.2	15	232.0	+1.8	+0.8
7-AR-7	AR	Conven.	4	235.7	6	225.0	-10.7	-4.5
7-AR-8	AR	Conven.	13	218.7	12	221.3	+2.6	+1.2
7-AR-9	AR	Conven.	7	192.4	14	201.3	+8.9	+4.6
7-AR-10	AR	Conven.	7	206.7	14	227.6	+20.9	+10.1
7-AR-11	AR	Conven.	7	182.5	14	181.5	-1.0	-0.5
7-IA-1	IA	Reduced	7	208.6	8	210.0	+1.4	+0.7
7-IA-2	IA	Reduced	4	200.0	3	203.3	+3.3	+1.7
7-IA-3	IA	Reduced	9	179.0	3	185.7	+6.7	+3.7
7-IA-4	IA	Reduced	8	197.0	7	192.6	-4.4	-2.2
7-IA-5	IA	Reduced	4	186.5	6	193.8	+7.3	+3.9
7-IA-6	IA	Reduced	9	218.0	7	231.6	+13.6	+6.2
7-IL-1	IL	Reduced	7	226.3	9	220.2	-6.1	-2.7
7-IL-2	IL	Reduced	9	208.7	6	208.8	+0.1	+0.1
7-IL-3	IL	Reduced	7	209.6	18	228.4	+18.8	+9.0
7-IL-4	IL	Reduced	3	242.5	6	246.3	+3.8	+1.6
7-IL-5	IL	Reduced	4	139.9	10	160.0	+20.1	+14.4
7-IL-6	IL	Reduced	7	162.6	16	206.7	+44.1	+27.1
7-IL-7	IL	Reduced	8	199.3	11	208.1	+8.8	+4.4
7-IL-8	IL	Reduced	5	195.7	16	192.8	-2.9	-1.5
7-IL-9	IL	Reduced	2	202.3	11	190.8	-11.5	-5.7
7-IL-10	IL	Reduced	4	172.0	17	177.4	+5.4	+3.1
7-IL-11	IL	Reduced	2	159.0	10	164.9	+5.9	+3.7

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	Tillage	# Trts.	Avg. Yield	# Trts.	Avg. Yield		
				(bu/A)		(bu/A)	(bu/A)	(%)
7-IL-12	IL	Reduced	4	182.8	6	187.5	+4.7	+2.6
7-IL-13	IL	Reduced	3	104.3	2	113.0	+8.7	+8.3
7-IL-14	IL	Reduced	5	183.8	9	188.3	+4.5	+2.4
7-IL-15	IL	Reduced	3	148.0	4	178.5	+30.5	+20.6
7-IL-16	IL	Reduced	8	150.3	9	164.6	+14.3	+9.5
7-IL-17	IL	Reduced	2	192.5	7	203.6	+11.1	+5.8
7-IL-18	IL	Reduced	7	201.4	10	204.5	+3.1	+1.5
7-IL-19	IL	No-Till	2	149.0	18	185.5	+36.5	+24.5
7-IL-20	IL	Reduced	9	211.4	7	210.5	-0.9	-0.4
7-IL-21	IL	Reduced	3	235.6	15	238.0	+2.4	+1.0
7-IL-22	IL	Reduced	6	220.5	9	220.5	+0.0	+0.0
7-IL-23	IL	Reduced	2	213.9	9	216.2	+2.3	+1.1
7-IL-24	IL	Reduced	2	246.5	7	245.7	-0.8	-0.3
7-KS-1	KS	Reduced	4	152.9	19	145.9	-7.0	-4.6
7-KS-2	KS	Conven.	2	241.9	9	249.2	+7.3	+3.0
7-KS_3	KS	Reduced	7	187.7	7	194.1	+6.4	+3.1
7-KY-1	KY	No-Till	5	149.0	11	174.3	+25.1	+17.0
7-KY-2	KY	No-Till	13	179.9	5	195.5	+15.6	+8.7
7-LA-1	LA	Conven.	3	164.4	3	169.5	+5.1	+3.1
7-LA-2	LA	Conven.	3	148.7	3	160.3	+11.6	+7.8
7-MD-1	MD	Conven.	4	69.6	5	66.3	-3.3	-4.7
7-MD-2	MD	Conven.	4	96.8	6	97.9	+1.1	+1.1
7-MD-3	MD	Conven.	7	74.4	2	93.3	+18.9	+25.4
7-MI-1	MI	Reduced	3	193.9	4	198.5	+4.6	+2.4
7-MN-1	MN	Conven.	9	191.3	12	193.0	+1.7	+0.9
7-MN-2	MN	Conven.	9	76.8	12	67.6	-9.2	-12.0
7-MN-3	MN	Conven.	9	187.8	12	189.8	+2.0	+1.1
7-MN-4	MN	Conven.	9	188.7	12	195.0	+6.3	+3.3
7-MN-5	MN	Conven.	9	162.6	12	162.6	+0.0	+0.0
7-MN-6	MN	Conven.	9	215.3	12	211.9	-3.4	-1.6
7-MN-7	MN	Conven.	8	177.6	7	178.0	+0.4	+0.2
7-MN-8	MN	Conven.	4	136.5	7	129.4	-7.1	-5.2
7-MN-9	MN	Conven.	4	55.3	7	65.1	+9.8	+17.7
7-MN-10	MN	Conven.	3	110.0	3	140.3	+30.3	+27.6
7-MN-11	MN	Conven.	8	75.4	7	72.1	-3.3	-4.4
7-MN-12	MN	Conven.	9	76.8	12	67.6	-9.2	-12.0
7-MN-13	MN	Conven.	9	191.3	12	193.0	+1.7	+0.9
7-MN-14	MN	Conven.	6	190.7	9	190.2	-0.5	-0.3
7-MO-1	MO	Conven.	4	171.0	9	173.9	+2.9	+1.7
7-MO-2	MO	Conven.	2	175.3	11	196.4	+21.1	+12.0
7-MO-3	MO	Conven.	2	152.9	9	155.0	+2.1	+1.4
7-MO-4	MO	Conven.	4	177.9	6	175.8	-2.1	-1.2
7-MO-5	MO	Conven.	12	159.3	4	172.9	+13.6	+8.5
7-MO-6	MO	No-Till	3	144.2	3	157.4	+13.2	+9.2
7-MO-7	MO	Conven.	6	180.4	9	183.6	+3.2	+1.8
7-MO-8	MO	Conven.	3	134.0	8	134.7	+0.7	+0.5
7-MO-9	MO	Conven.	5	177.7	7	177.7	+0.0	+0.0
7-MS-1	MS	Conven.	3	227.9	3	246.1	+18.2	+8.0
7-MS-2	MS	No-Till	7	144.2	4	154.7	+10.5	+7.3
7-NE-1	NE	Conven.	2	118.3	7	114.3	-4.0	-3.4
7-NE-2	NE	Reduced	3	216.7	9	229.3	+12.6	+5.8
7-NE-3	NE	Conven.	8	66.8	3	79.6	+12.8	+19.2

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	Tillage	# Trts.	Avg. Yield	# Trts.	Avg. Yield		
				(bu/A)		(bu/A)	(bu/A)	(%)
7-NE-4	NE	Conven.	8	134.1	3	129.9	-4.2	-3.1
7-NE-5	NE	Reduced	5	223.6	10	223.8	+0.2	+0.1
7-NE-6	NE	Reduced	11	113.2	8	97.7	-15.5	-13.7
7-NE-7	NE	No-Till	3	120.6	4	120.4	-0.2	-0.2
7-NE-8	NE	No-Till	4	123.6	4	124.3	+0.7	+0.6
7-NE-9	NE	Reduced	4	159.6	7	165.1	+5.5	+3.4
7-NE-10	NE	Conven.	5	185.8	17	185.7	-0.1	-0.1
7-NY-1	NY	Conven.	9	131.9	3	129.5	-2.4	-1.8
7-OH-1	OH	Conven.	7	215.8	7	218.1	+2.3	+1.1
7-OH-2	OH	Conven.	13	224.5	5	227.1	+2.6	+1.2
7-SD-1	SD	Conven.	8	128.6	9	135.8	+7.2	+5.6
7-SD-2	SD	Conven.	4	136.3	2	141.5	+5.2	+3.8
7-SD-3	SD	Conven.	9	142.1	5	146.0	+3.9	+2.7
7-SD-4	SD	Conven.	10	130.2	3	132.0	+1.8	+1.4
7-SD-5	SD	Conven.	7	151.3	8	151.0	-0.3	-0.2
7-SD-6	SD	Conven.	6	102.0	3	113.7	+11.7	+11.5
7-TN-1	TN	No-Till	3	62.7	3	68.4	+5.7	+9.1
7-TN-2	TN	No-Till	3	72.2	3	72.1	-0.1	-0.1
7-TN-3	TN	No-Till	2	75.4	11	87.1	+11.7	+15.5
7-TX-1	TX	Conven.	3	136.4	4	137.4	+1.0	+0.7
7-TX-2	TX	Conven.	4	159.5	4	161.7	+2.2	+1.4
7-WI-1	WI	Conven.	3	162.1	3	170.0	+7.9	+4.9
7-WI-2	WI	Conven.	19	166.6	12	167.6	+1.0	+0.6
2008								
8-AR-1	AR	Conven.	4	189.8	11	184.8	-5.0	-2.6
8-AR-2	AR	Conven.	3	180.5	12	181.6	+1.1	+0.6
8-AR-3	AR	Conven.	4	175.8	6	192.2	+16.4	+9.3
8-AR-4	AR	Conven.	10	187.7	12	191.8	+4.1	+2.2
8-AR-5	AR	Conven.	4	156.8	11	164.4	+7.6	+4.8
8-AR-6	AR	Conven.	4	176.7	4	174.9	-1.8	-1.0
8-AR-7	AR	Conven.	8	197.8	10	203.9	+6.1	+3.1
8-AR-8	AR	Conven.	5	196.2	7	206.6	+10.4	+5.3
8-AR-9	AR	Conven.	6	219.3	13	219.1	-0.2	-0.1
8-AR-10	AR	Conven.	6	193.8	13	207.1	+13.3	+6.9
8-AR-11	AR	Conven.	6	191.2	3	186.6	-4.6	-2.4
8-DE-1	DE	Conven.	2	145.6	8	204.1	+58.5	+40.2
8-IA-1	IA	Reduced	7	216.7	3	220.0	+3.3	+1.5
8-IA-2	IA	Reduced	8	193.0	6	188.2	-4.8	-2.5
8-IA-3	IA	Reduced	4	188.3	6	198.2	+9.9	+5.3
8-IA-4	IA	Reduced	3	200.7	7	211.3	+10.6	+5.3
8-IA-5	IA	Reduced	4	204.8	6	203.2	-1.6	-0.8
8-IA-6	IA	Reduced	8	210.4	8	217.8	+7.4	+3.5
8-IA-7	IA	Reduced	5	214.0	9	205.1	-8.9	-4.2
8-IA-8	IA	Reduced	2	222.5	4	232.3	+9.8	+4.4
8-IL-1	IL	Reduced	8	214.0	8	211.8	-2.2	-1.0
8-IL-2	IL	Reduced	8	134.4	8	132.8	-1.6	-1.2
8-IL-3	IL	Reduced	8	234.0	8	232.0	-2.0	-0.9
8-IL-4	IL	Reduced	2	184.6	9	191.3	+6.7	+3.6
8-IL-5	IL	Reduced	10	179.4	7	181.5	+2.1	+1.2
8-IL-6	IL	Reduced	4	185.5	7	190.6	+5.1	+2.7
8-IL-7	IL	Reduced	17	206.7	3	222.1	+15.4	+7.5

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	Tillage	# Trts.	Avg. Yield	# Trts.	Avg. Yield		
				(bu/A)		(bu/A)	(bu/A)	(%)
8-IL-8	IL	Reduced	7	202.7	15	215.7	+13.0	+6.4
8-IL-9	IL	Reduced	4	208.5	6	207.5	-1.0	-0.5
8-IL-10	IL	Reduced	9	222.4	7	227.6	+5.2	+2.3
8-IL-11	IL	No-Till	9	67.6	6	67.0	-0.6	-0.9
8-IL-12	IL	Reduced	4	176.1	5	176.0	-0.1	-0.1
8-IL-13	IL	Reduced	7	236.9	3	238.2	+1.3	+0.5
8-IL-14	IL	Reduced	5	249.0	7	250.5	+1.5	+0.6
8-IL15	IL	Reduced	2	248.3	8	245.7	-2.6	-1.0
8-KS-1	KS	Conven.	10	153.1	18	158.4	+5.3	+3.5
8-KS-2	KS	Conven.	10	165.6	10	157.1	-8.5	-5.1
8-KS-3	KS	Conven.	10	143.1	12	153.8	+10.7	+7.5
8-KS-4	KS	Conven.	3	179.7	20	182.7	+3.0	+1.7
8-KS-5	KS	Conven.	6	221.7	2	224.7	+3.0	+1.4
8-KY-1	KY	Reduced	9	135.3	6	138.5	+3.2	+2.4
8-KY-2	KY	No-Till	9	139.7	8	141.9	+2.2	+1.6
8-LA-1	LA	Conven.	4	168.5	9	192.2	+23.7	+14.1
8-MD-1	MD	Conven.	7	146.4	6	154.7	+8.3	+5.7
8-MD-2	MD	Conven.	2	197.7	9	193.0	-4.7	-2.4
8-MD-3	MD	Conven.	2	158.7	13	208.7	+50.0	+31.5
8-MD-4	MD	Conven.	3	123.3	9	120.8	-2.5	-2.0
8-MI-1	MI	Conven.	8	227.4	7	223.5	-3.9	-1.7
8-MI-2	MI	Conven.	7	209.8	3	213.8	+4.0	+1.9
8-MN-1	MN	Conven.	7	140.4	3	153.0	+12.6	+9.0
8-MN-2	MN	Conven.	6	175.8	17	168.2	-7.6	-4.3
8-MN-3	MN	Conven.	10	167.4	10	166.3	-1.1	-0.7
8-MN-4	MN	Conven.	3	158.7	6	157.0	-1.7	-1.1
8-MN-5	MN	Conven.	7	212.6	3	224.3	+11.7	+5.5
8-MN-6	MN	Conven.	16	117.3	11	118.1	+0.8	+0.7
8-MN-7	MN	Conven.	7	140.4	3	153.0	+12.6	+9.0
8-MN-8	MN	Conven.	11	182.8	10	184.2	+1.4	+0.8
8-MN-9	MN	Conven.	11	126.2	10	124.1	-2.1	-1.7
8-MN-10	MN	Conven.	18	116.9	9	117.8	+0.9	+0.8
8-MN-11	MN	Conven.	10	167.9	10	165.5	-2.4	-1.4
8-MO-1	MO	No-Till	7	198.2	3	202.5	+4.3	+2.2
8-MO-2	MO	Conven.	3	115.4	17	127.9	+12.5	+10.8
8-MO-3	MO	Conven.	2	113.5	9	125.8	+12.3	+10.8
8-MO-4	MO	Conven.	4	146.6	13	146.6	+0.0	+0.0
8-MO-5	MO	Conven.	17	100.4	6	126.5	+26.1	+26.0
8-MO-6	MO	Conven.	2	84.6	10	98.7	+14.1	+16.7
8-MO-7	MO	Conven.	2	168.4	4	164.4	-4.0	-2.4
8-MS-1	MS	Conven.	4	180.5	9	176.8	-3.7	-2.0
8-MS-2	MS	Reduced	5	136.9	10	151.7	+14.8	+10.8
8-NC-1	NC	Conven.	4	181.9	11	187.3	+5.4	+3.0
8-NE-1	NE	Reduced	3	229.1	20	227.4	-1.7	-0.7
8-NE-2	NE	Reduced	7	169.8	5	169.5	-0.3	-0.2
8-NE-3	NE	Reduced	19	179.1	2	204.8	+25.7	+14.3
8-NE-4	NE	Reduced	2	172.3	7	182.3	+10.0	+5.8
8-NE-5	NE	Reduced	4	172.2	7	173.0	+0.8	+0.5
8-NE-6	NE	Reduced	3	195.8	4	205.9	+10.1	+5.2
8-NE-7	NE	Reduced	10	187.0	6	192.3	+5.3	+2.8
8-NE-8	NE	Conven.	2	239.3	5	236.8	-2.5	-1.0
8-NY-1	NY	Conven.	7	213.8	8	220.1	+6.3	+2.9

			Non-Atrazine		**Atrazine**		**Yield Difference With Atrazine**	
Study	**State**	**Tillage**	**# Trts.**	**Avg. Yield**	**# Trts.**	**Avg. Yield**		
				(bu/A)		**(bu/A)**	**(bu/A)**	**(%)**
8-NY-2	NY	Conven.	9	196.0	9	191.0	-5.0	-2.6
8-OH-1	OH	Conven.	8	114.3	10	129.7	+15.4	+13.5
8-PA-1	PA	Conven.	7	173.7	6	182.0	+8.3	+4.8
8-PA-2	PA	Conven.	5	163.9	7	160.6	-3.3	-2.0
8-SD-1	SD	Conven.	2	168.5	6	171.3	+2.8	+1.7
8-SD-2	SD	Conven.	6	191.3	6	196.8	+5.5	+2.9
8-SD-3	SD	Conven.	7	202.7	6	201.4	-1.3	-0.6
8-TN-1	TN	No-Till	4	166.7	9	168.1	+1.4	+0.8
8-TX-1	TX	Conven.	4	147.9	9	148.0	+0.1	+0.1
8-TX-2	TX	Conven.	6	165.7	10	176.8	+11.1	+6.7
8-WI-1	WI	Conven.	7	168.5	5	167.5	-1.0	-0.6
8-WI-2	WI	Conven.	3	130.8	6	142.5	+11.7	+8.9
2009								
9-AR-1	AR	Conven.	3	170.3	8	165.2	-5.1	-3.0
9-AR-2	AR	Conven.	4	200.5	4	196.8	-3.7	-1.8
9-AR-3	AR	Conven.	6	183.7	9	188.4	+4.7	+2.6
9-AR-4	AR	Conven.	3	184.3	11	193.5	+9.2	+5.0
9-AR-5	AR	Conven.	17	203.4	14	205.6	+2.2	+1.1
9-AR-6	AR	Conven.	14	217.5	15	221.9	+4.4	+2.0
9-AR-7	AR	Conven.	3	153.0	4	157.5	+4.5	+2.9
9-AR-8	AR	Conven.	4	154.0	7	161.6	+7.6	+4.9
9-AR-9	AR	Conven.	7	173.7	5	173.2	-0.5	-0.3
9-AR-10	AR	Conven.	6	155.3	5	151.2	-4.1	-2.6
9-IA-1	IA	Reduced	5	204.6	10	204.5	-0.1	-0.0
9-IA-2	IA	Reduced	4	186.0	7	216.6	+30.6	+16.5
9-IA-3	IA	Reduced	8	205.1	4	208.3	+3.2	+1.6
9-IA-4	IA	Reduced	6	206.0	4	199.5	-6.5	-3.2
9-IL-1	IL	Reduced	10	203.6	8	212.9	+9.3	+4.6
9-IL-2	IL	Reduced	9	167.3	5	166.2	-1.1	-0.7
9-IL-3	IL	Reduced	2	172.0	8	165.4	-6.6	-3.8
9-IL-4	IL	Reduced	9	157.1	14	166.6	+9.5	+6.0
9-IL-5	IL	Reduced	11	204.0	6	204.5	+0.5	+0.2
9-IL-6	IL	Reduced	7	219.9	8	218.0	-1.9	-0.9
9-IL-7	IL	Reduced	4	230.5	5	225.4	-5.1	-2.2
9-IL-8	IL	Reduced	2	204.0	7	211.9	+7.9	+3.9
9-IL-9	IL	Reduced	17	110.7	2	110.0	-0.7	-0.6
9-IL-10	IL	Reduced	17	116.1	2	127.5	+11.4	+9.8
9-IL-11	IL	Reduced	5	105.0	12	108.3	+3.3	+3.1
9-IL-12	IL	Reduced	4	102.0	5	101.0	-1.0	-1.0
9-IL-13	IL	Reduced	3	260.0	10	260.0	+0.0	+0.0
9-IL-14	IL	Reduced	2	244.5	9	253.0	+8.5	+3.5
9-IL-15	IL	Reduced	4	231.3	8	230.6	-0.7	-0.3
9-IL-16	IL	Reduced	2	231.0	5	234.2	+3.2	+1.4
9-IN-1	IN	Conven.	2	245.5	11	252.6	+7.1	+2.9
9-IN-2	IN	Conven.	6	248.8	5	257.4	+8.6	+3.5
9-IN-3	IN	Conven.	4	250.5	2	248.5	-2.0	-0.8
9-IN-4	IN	Conven.	7	203.4	3	197.3	-6.1	-3.0
9-IN-5	IN	No-Till	3	36.3	5	53.2	+16.9	+46.6
9-KS-1	KS	Conven.	12	207.7	18	217.1	+9.4	+4.5
9-KS-2	KS	No-Till	2	90.5	7	93.4	+2.9	+3.2
9-KY-1	KY	Reduced	3	222.7	4	221.3	-1.4	-0.6
9-KY-2	KY	No-Till	5	214.0	10	214.7	+0.7	+0.3

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	Tillage	# Trts.	Avg. Yield	# Trts.	Avg. Yield		
				(bu/A)		(bu/A)	(bu/A)	(%)
9-KY-3	KY	Conven.	4	210.3	11	214.9	+4.6	+2.2
9-MD-1	MD	Conven.	4	167.5	10	184.7	+17.2	+10.3
9-MD-2	MD	Conven.	3	216.0	5	224.8	+8.8	+4.1
9-MD-3	MD	Conven.	5	170.2	9	168.9	-1.3	-0.8
9-MD-4	MD	Conven.	2	162.5	10	172.5	+10.0	+6.2
9-MD-5	MD	No-Till	2	115.0	10	133.0	+18.0	+15.7
9-MD-6	MD	Conven.	5	135.6	9	147.8	+12.2	+9.0
9-MD-7	MD	Conven.	2	124.0	9	131.6	+7.6	+6.1
9-MD-8	MD	Conven.	5	153.0	6	151.0	-2.0	-1.3
9-MI-1	MI	Reduced	6	237.7	4	246.0	+8.3	+3.5
9-MI-2	MI	Reduced	4	238.3	3	235.3	-3.0	-1.3
9-MI-3	MI	Reduced	2	260.5	4	254.5	-6.0	-2.3
9-MI-4	MI	Reduced	7	227.3	8	226.6	-0.7	-0.3
9-MI-5	MI	Conven.	8	233.9	4	233.0	-0.9	-0.4
9-MI-6	MI	Conven.	8	217.9	15	217.7	-0.2	-0.0
9-MI-7	MI	Conven.	8	230.1	25	230.4	+0.3	+0.1
9-MN-1	MN	Reduced	13	159.2	9	164.6	+5.4	+3.4
9-MN-2	MN	Reduced	13	203.5	9	203.7	+0.2	+0.0
9-MN-3	MN	Conven.	6	160.5	2	174.0	+13.5	+8.4
9-MN-4	MN	Conven.	6	180.7	5	170.4	-10.3	-5.7
9-MN-5	MN	Reduced	11	199.4	6	197.0	-2.4	-1.2
9-MN-6	MN	Conven.	5	174.2	2	212.0	+37.8	+21.7
9-MN-7	MN	Conven.	10	171.0	5	170.6	-0.4	-0.2
9-MN-8	MN	Reduced	7	203.7	8	201.0	-2.7	-1.3
9-MN-9	MN	Reduced	3	221.0	7	218.3	-2.7	-1.2
9-MN-10	MN	Reduced	13	189.2	9	187.7	-1.5	-0.8
9-MO-1	MO	Conven.	3	141.7	7	137.9	-3.8	-2.7
9-MO-2	MO	Conven.	6	119.3	2	133.0	+13.7	+11.5
9-MO-3	MO	Conven.	4	137.5	2	141.5	+4.0	+2.9
9-MO-4	MO	Conven.	4	49.8	6	48.3	-1.5	-3.0
9-MO-5	MO	Conven.	5	147.8	3	164.7	+16.9	+11.4
9-MO-6	MO	No-Till	2	108.0	4	114.0	+6.0	+5.6
9-MO-7	MO	Conven.	3	137.0	2	141.5	+4.5	+3.3
9-MO-8	MO	Conven.	5	162.8	10	157.5	-5.3	-3.3
9-NE-1	NE	Reduced	4	185.8	7	184.0	-1.8	-1.0
9-NE-2	NE	Reduced	5	190.4	4	189.8	-0.6	-0.3
9-NE-3	NE	Reduced	2	175.0	10	178.5	+3.5	+2.0
9-NE-4	NE	Reduced	5	182.8	6	180.2	-2.4	-1.3
9-NE-5	NE	Reduced	2	187.0	7	186.9	-0.1	-0.0
9-NE-6	NE	Reduced	6	178.7	5	178.4	-0.3	-0.2
9-NE-7	NE	Reduced	6	270.5	6	262.8	-7.7	-2.8
9-NE-8	NE	Reduced	5	255.2	7	254.3	-0.9	-0.4
9-NE-9	NE	Reduced	2	235.5	9	240.7	+5.2	+2.2
9-NE-10	NE	Reduced	10	227.5	2	224.5	-3.0	-1.3
9-NE-11	NE	Reduced	5	240.2	5	245.8	+5.6	+2.3
9-NE-12	NE	Reduced	6	145.2	8	145.9	+0.6	+0.4
9-NE-13	NE	Reduced	2	142.0	8	146.4	+4.4	+3.1
9-NE-14	NE	No-Till	6	144.2	2	145.5	+1.3	+0.9
9-NE-15	NE	No-Till	4	147.8	4	148.8	+1.0	+0.7
9-NE-16	NE	Reduced	7	160.4	8	199.6	+39.2	+24.5
9-OH-1	OH	Conven.	2	240.5	9	267.7	+27.2	+11.3
9-OH-2	OH	Conven.	2	257.0	7	274.1	+17.1	+6.7

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	**State**	**Tillage**	**# Trts.**	**Avg. Yield**	**# Trts.**	**Avg. Yield**		
				(bu/A)		**(bu/A)**	**(bu/A)**	**(%)**
9-OH-3	OH	Conven.	5	266.4	8	269.0	+2.6	+1.0
9-OH-4	OH	Conven.	2	259.0	11	267.5	+8.5	+3.3
9-OH-5	OH	Conven.	5	268.2	8	270.9	+2.7	+1.0
9-OH-6	OH	No-Till	5	167.4	7	198.6	+31.2	+18.6
9-OH-7	OH	Conven.	3	221.7	5	216.4	-5.3	-2.4
9-OH-8	OH	Conven.	3	249.3	4	250.3	+1.0	+0.4
9-SD-1	SD	Conven.	5	192.6	5	193.4	+0.8	+0.4
9-SD-2	SD	Conven.	3	191.0	4	190.5	-0.5	-0.3
9-SD-3	SD	Conven.	5	188.0	2	192.5	+4.5	+2.4
9-SD-4	SD	Conven.	7	196.0	2	197.5	+1.5	+0.8
9-SD-5	SD	Conven.	4	187.5	7	192.3	+4.8	+2.6
9-SD-6	SD	Conven.	5	193.0	5	190.2	-2.8	-1.5
9-SD-7	SD	Conven.	5	132.8	10	143.1	+10.3	+7.8
9-SD-8	SD	Conven.	5	186.2	10	182.9	-3.3	-1.8
9-SD-9	SD	Conven.	5	171.0	10	169.0	-2.0	-1.2
9-TN-1	TN	No-Till	3	204.7	2	208.0	+3.3	+1.6
9-TX-1	TX	Conven.	7	175.6	2	190.5	+14.9	+8.5
9-WI-1	WI	Conven.	9	175.6	7	170.0	-5.6	-3.2
2010								
10-AR-1	AR	Conven.	4	107.5	4	109.3	+1.8	+1.7
10-AR-2	AR	Conven.	15	144.5	14	157.1	+12.6	+8.7
10-AR-3	AR	Conven.	9	130.0	14	126.4	-3.6	-2.8
10-AR-4	AR	Conven.	15	148.4	14	148.4	+0.0	+0.0
10-IA-1	IA	Reduced	2	195.0	6	183.5	-11.5	-5.9
10-IA-2	IA	Reduced	5	195.4	4	195.5	+0.1	+0.0
10-IA-3	IA	Reduced	2	172.0	6	173.8	+1.8	+1.0
10-IA-4	IA	Reduced	5	158.0	4	168.0	+10.0	+6.3
10-IA-5	IA	Reduced	4	167.8	6	172.7	+4.9	+2.9
10-IA-6	IA	Reduced	2	153.5	6	159.2	+5.7	+3.7
10-IL-1	IL	Reduced	4	182.3	7	182.7	+0.4	+0.2
10-IL-2	IL	Reduced	12	179.1	3	187.0	+7.9	+4.4
10-IL-3	IL	Reduced	5	161.8	14	161.8	+0.0	+0.0
10-IL-4	IL	Reduced	4	145.5	6	154.0	+8.5	+5.8
10-IL-5	IL	Reduced	12	128.8	3	145.0	+16.2	+12.6
10-IL-6	IL	Reduced	5	166.0	14	168.0	+2.0	+1.2
10-IL-7	IL	Reduced	9	191.0	2	200.5	+9.5	+5.0
10-IL-8	IL	Reduced	14	194.3	6	199.5	+5.2	+2.7
10-IL-9	IL	Reduced	4	185.3	10	182.1	-3.2	-1.7
10-IL-10	IL	Reduced	11	180.9	4	181.8	+0.9	+0.5
10-IL-11	IL	Reduced	10	204.7	13	205.3	+0.6	+0.3
10-IL-12	IL	Reduced	17	204.0	6	214.3	+10.3	+5.0
10-IL-13	IL	Reduced	4	195.5	14	203.1	+7.6	+3.9
10-IL-14	IL	Reduced	5	157.8	5	155.6	-2.2	-1.4
10-IL-15	IL	Reduced	4	153.5	4	148.3	-5.2	-3.4
10-IL-16	IL	Reduced	9	149.9	14	160.1	+10.2	+6.8
10-IL-17	IL	Reduced	2	157.5	6	154.7	-2.8	-1.8
10-IL-18	IL	Reduced	4	117.0	4	120.5	+3.5	+3.0
10-IL-19	IL	No-Till	3	182.7	3	189.0	+6.3	+3.4
10-IL-20	IL	Reduced	3	137.3	8	139.3	+2.0	+1.5
10-IL-21	IL	Reduced	2	123.5	8	127.0	+3.5	+2.8
10-IL-22	IL	Reduced	4	109.0	6	126.2	+17.2	+15.8
10-IN-1	IN	Conven.	10	184.6	7	210.0	+25.4	+13.8

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	Tillage	# Trts.	Avg. Yield	# Trts.	Avg. Yield		
				(bu/A)		(bu/A)	(bu/A)	(%)
10-IN-2	IN	Conven.	3	204.3	4	202.0	-2.3	-1.1
10-IN-3	IN	Conven.	7	176.6	2	179.5	+2.9	+1.6
10-IN-4	IN	Conven.	5	181.4	9	185.8	+4.4	+2.4
10-IN-5	IN	Conven.	3	164.3	8	175.1	+10.8	+6.6
10-IN-6	IN	Conven.	4	197.5	5	188.2	-9.3	-4.7
10-IN-7	IN	Conven.	6	203.5	8	215.3	+11.8	+5.8
10-IN-8	IN	No-Till	8	132.0	8	134.1	+2.1	+1.6
10-KS-1	KS	Conven.	11	115.5	16	112.9	-2.6	-2.3
10-KS-2	KS	Conven.	12	131.3	15	137.7	+6.4	+4.9
10-KS-3	KS	No-Till	3	67.0	6	69.3	+2.3	+3.4
10-MD-1	MD	Conven.	7	94.0	3	86.3	-7.7	-8.2
10-MD-2	MD	Conven.	3	77.3	2	94.5	+17.2	+22.3
10-MD-3	MD	Conven.	4	119.8	5	120.8	+1.0	+0.8
10-MI-1	MI	Conven.	11	223.3	10	229.7	+6.4	+2.9
10-MI-2	MI	Conven.	4	221.8	5	220.4	-1.4	-0.6
10-MI-3	MI	Conven.	7	208.9	18	206.9	-2.0	-1.0
10-MI-4	MI	Conven.	2	215.5	6	216.5	+1.0	+0.5
10-MN-1	MN	Reduced	17	163.6	4	170.8	+7.2	+4.4
10-MN-2	MN	Reduced	18	228.8	4	229.0	+0.2	+0.0
10-MN-3	MN	Reduced	12	209.3	3	212.7	+3.4	+1.6
10-MN-4	MN	Reduced	5	223.2	2	227.0	+3.8	+1.7
10-MN-5	MN	Reduced	5	224.2	3	231.3	+7.1	+3.2
10-MN-6	MN	Reduced	17	196.7	5	202.8	+6.1	+3.1
10-MO-1	MO	No-Till	3	73.0	6	67.5	-5.5	-7.5
10-MO-2	MO	Conven.	3	120.0	12	117.1	-2.9	-2.4
10-MS-1	MS	Conven.	3	176.0	7	173.3	-2.7	-1.5
10-MS-2	MS	Conven.	3	155.0	5	156.0	+1.0	+0.6
10-NC-1	NC	No-Till	7	80.7	5	79.6	-0.4	-0.5
10-NE-1	NE	Conven.	4	222.3	8	219.8	-2.5	-1.1
10-OH-1	OH	Conven.	7	250.0	6	251.5	+1.5	+0.6
10-OH-2	OH	Conven.	5	252.8	9	251.2	-1.6	-0.6
10-OH-3	OH	Conven.	9	229.7	8	234.1	+4.4	+1.9
10-OH-4	OH	Conven.	4	245.5	10	242.6	-2.9	-1.2
10-OH-5	OH	No-Till	4	136.8	7	161.0	+24.2	+17.7
10-PA-1	PA	No-Till	7	166.7	8	176.3	+9.6	+5.8
10-PA-2	PA	Conven.	4	219.3	5	221.0	+1.7	+0.8
10-PA-3	PA	Conven.	9	206.6	6	209.7	+3.1	+1.5
10-SD-1	SD	Conven.	2	151.0	6	161.7	+10.7	+7.1
10-SD-2	SD	Conven.	7	198.1	5	196.4	-1.7	-0.9
10-SD-3	SD	Conven.	2	181.0	6	184.0	+4.0	+2.2
10SD-4	SD	Conven.	5	140.2	2	165.0	+24.8	+17.7
10-SD-5	SD	Conven.	6	196.8	6	198.2	+1.4	+0.7
10-SD-6	SD	Conven.	8	177.5	5	176.2	-1.3	-0.7
10-SD-7	SD	Conven.	4	94.5	4	103.5	+9.0	+9.5
10-SD-8	SD	Conven.	3	177.0	3	169.0	-8.0	-4.5
10-SD-9	SD	Conven.	5	167.0	10	168.6	+1.6	+1.0
10-SD-10	SD	Conven.	5	154.4	10	158.6	+4.2	+2.7
10-SD-11	SD	Conven.	5	180.4	10	179.5	-0.9	-0.5
10-TX-1	TX	Conven.	3	100.0	6	104.7	+4.7	+4.7
10-WI-1	WI	Conven.	6	216.8	8	220.0	+3.2	+1.5
10-WI-2	WI	Conven.	9	227.8	3	232.0	+4.2	+1.8
10-WI-3	WI	Conven.	8	204.3	9	213.1	+8.8	+4.3

			Non-Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	Tillage	# Trts.	Avg. Yield	# Trts.	Avg. Yield		
				(bu/A)		(bu/A)	(bu/A)	(%)
10-WI-4	WI	Conven.	8	210.3	9	212.8	+2.5	+1.2

2006 to 2010 Overall Average = 4.9 bu/A (3.3%) Increase in Yield with Atrazine
2006 to 2010 Conventional Tillage Average = 4.6 bu/A (3.1%) Increase in Yield with Atrazine
2006 to 2010 Reduced Tillage Average = 4.4 bu/A (2.7%) Increase in Yield with Atrazine
2006 to 2010 No-Till Average = 8.1 bu/A (6.7%) Increase in Yield with Atrazine

Table 2. U.S. sorghum yields with and without atrazine, 2006-2010.

		Non Atrazine		Atrazine		Yield Difference With Atrazine	
Study	State	# Trts.	Avg. Yield	# Trts.	Avg. Yield		
			(bu/A)		(bu/A)	(bu/A)	(%)
S7-AR-1	AR	4	19.7	7	19.3	-0.4	-2.0
S7-AR-2	AR	2	26.8	5	32.3	+5.5	+20.5
S7-KS-1	KS	2	57.6	12	60.5	+2.9	+5.0
S7-KS-2	KS	2	129.0	12	143.7	+14.7	+11.4
S7-KS-3	KS	2	121.2	12	139.4	+18.2	+15.0
S7-KS-4	KS	2	107.7	12	117.6	+9.9	+9.2
S8-KS-1	KS	2	130.9	12	135.1	+4.2	+3.2
S9-AR-1	AR	3	98.2	5	107.7	+9.5	+9.7
S9-TX-1	TX	2	56.4	3	57.1	+0.7	+1.2
S9-TX-2	TX	2	97.7	3	101.0	+3.3	+3.4
S10-NE-1	NE	4	164.3	7	163.8	-0.5	-0.3
S10-SD-1	SD	3	81.3	11	81.9	+0.6	+0.7

2006 to 2010 Average = 5.7 bu/A (6.4%) Increase in Yield with Atrazine

Table 3. Herbicide products used in 2010 university corn experiments in treatments either with or without atrazine. Only products used in at least five treatments are listed.

	With Atrazine		Without Atrazine	
Trade Name	# Trts.	% of Total Trts.	# Trts.	% of Total Trts.
Atrazine-Containing Products				
AAtrex/atrazine	336	56.0	-	-
Bicep II Magnum	63	10.5	-	-
Callisto Xtra	26	4.3	-	-
Cinch ATZ	13	2.2	-	-
Guardsman Max	32	5.3	-	-
Harness Xtra	63	10.5	-	-
Lexar	49	8.2	-	-
Lumax	53	8.8	-	-
Non-Atrazine Containing Products				
Glyphosate Products				
Abundit Extra	14	2.3	31	5.6
Durango	14	2.3	59	10.7
Glypos Extra	1	0.2	5	0.9
Roundup	166	27.7	221	40.0
Touchdown Total	147	24.5	73	13.2
Other Products				
Balance Flex/isoxaflutole	49	8.2	45	8.2
Breakfree	0	0	10	1.8
Cadet	7	1.2	7	1.3
Callisto/mesotrione	11	1.8	25	4.5
Capreno	31	5.2	55	10.0
Corvus	47	7.8	63	11.4
2,4-D ester	11	1.8	11	2.0
Dual II Magnum	35	8.2	21	3.8
Fierce	10	1.7	5	0.9
Gramoxone	5	0.8	2	0.4
Halex	83	13.8	33	6.0
Harmony	5	0.8	1	0.2
Harness	6	1.0	23	4.2
Hornet	6	1.0	1	0.2
Ignite	38	6.3	42	7.6
Impact	51	8.5	27	4.9
Integrity	9	1.5	53	9.6
Laudis	53	8.8	37	6.7
Northstar	7	1.2	6	1.1
Prequel	3	0.5	7	1.3
Prowl	3	0.5	8	1.4
Realm Q	9	1.5	20	3.6
Resolve Q	25	4.2	21	3.8
Rimsulfuron	4	0.7	13	2.4
Samson	5	0.8	4	0.7
Sharpen	14	2.3	10	1.8
Status	21	3.5	41	7.4
SureStart	10	1.7	74	13.4
Verdict	0	0	12	2.2

Table 4. Herbicide active ingredients used in 2010 university corn experiments in treatments either with or without atrazine. Only active ingredients used in at least 5 treatments are listed.

	With Atrazine		**Without Atrazine**	
Active Ingredient	**# Trts.**	**% of Total Trts.**	**# Trts.**	**% of Total Trts.**
acetochlor	79	13.2	107	19.4
chlopyralid	16	2.7	75	13.6
dicamba	7	1.2	29	5.3
diflufenzopyr	0	0.0	23	4.2
dimethenamid-p	41	6.8	65	11.8
flufenacet-methyl	7	1.2	7	1.3
flumetsulam	16	2.7	75	13.6
flumioxazin	10	1.7	5	0.9
glufosinate	38	6.3	42	7.6
glyphosate	425	78.8	422	80.1
isoxaflutole	99	16.5	115	20.8
s-metolachlor	296	49.3	54	9.8
mesotrione	231	38.5	78	14.1
paraquat	5	0.8	2	0.4
pendimethalin	3	0.5	8	1.4
primisulfuron	7	1.2	6	1.1
rimsulfuron	41	6.8	61	11.1
saflufenacil	23	3.8	75	13.6
tembotrione	84	14.0	92	16.7
thiencarbazone-methyl	78	13.0	118	21.4
thifensulfuron	30	5.0	22	4.0
topramezone	51	8.5	27	4.9

Table 5. Active ingredients, application trips and atrazine active rate comparisons in 1986, 2001, and 2010 corn studies. Data for 1986 and 2001 are from Fawcett, R.S. 2008, Twenty years of university corn yield data: with and without atrazine. Proc. NCWSS.

Study	State	Non-Atrazine Avg.			Atrazine Avg.			Atra. Rate
		# Trts.	Actives	Trips	# Trts.	Actives	Trips	
								lb/A
1986								
1986-1	WI	25	2.50	2.00	14	2.85	2.00	0.74
1986-2	IL	3	2.00	1.00	12	2.00	1.00	2.01
1986-3	WI	7	2.00	1.00	29	2.25	1.04	1.43
1986-4	MN	8	2.00	1.57	3	3.00	1.33	0.81
1986-5	MN	17	2.06	1.31	5	3.00	1.20	0.67
1986-6	NE	2	2.00	1.50	13	2.31	1.31	1.28
1986-7	MN	12	2.00	1.50	16	2.44	1.25	1.30
1986-8	NE	8	2.13	1.75	10	2.90	2.00	1.09
Average			**2.09**	**1.45**		**2.59**	**1.39**	**1.17**
2001								
2001-1	SD	18	1.94	1.55	2	3.50	1.50	0.88
2001-2	IL	8	2.00	2.00	2	2.00	2.00	1.50
2001-3	IL	18	4.00	1.00	2	4.00	1.00	0.88
2001-4	IL	2	2.00	1.50	3	3.00	1.67	0.67
2001-5	IA	3	2.33	1.67	6	3.00	1.67	1.00
2001-6	IL	5	1.60	1.00	6	2.67	1.0	1.00
2001-7	IA	3	2.33	1.67	6	3.00	1.67	1.00
2001-8	IL	3	2.00	1.67	8	3.13	1.50	0.93
2001-9	MN	8	3.63	1.88	13	4.08	1.62	0.60
2001-10	MN	8	3.63	1.88	13	4.08	1.62	0.60
2001-11	MN	8	3.63	1.88	13	4.08	1.62	0.60
Average			**2.64**	**1.61**		**3.32**	**1.53**	**0.88**
2010								
10-AR-1	AR	4	2.75	2.00	4	3.50	2.00	1.19
10-AR-2	AR	15	2.33	1.40	14	3.07	1.50	1.56
10-AR-3	AR	9	2.33	1.22	14	3.64	1.43	1.31
10-AR-4	AR	15	2.33	1.47	14	3.07	1.36	1.49
10-IA-1	IA	2	3.50	2.00	6	3.67	2.00	0.86
10-IA-2	IA	5	2.40	1.20	4	3.75	1.00	0.47
10-IA-3	IA	2	2.00	2.00	6	3.50	2.00	0.50
10-IA-4	IA	5	2.40	1.20	4	3.75	1.00	0.47
10-IA-5	IA	4	2.00	1.00	6	3.33	1.00	0.52
10-IA-6	IA	2	3.50	2.00	6	3.67	2.00	0.91
10-IL-1	IL	4	3.75	1.00	7	4.43	1.00	1.08
10-IL-2	IL	12	2.50	1.08	3	4.00	1.00	0.50
10-IL-3	IL	5	3.80	2.00	14	4.14	2.00	0.71
10-IL-4	IL	4	2.00	1.00	6	3.50	1.00	0.52
10-IL-5	IL	12	2.50	1.08	3	4.00	1.00	0.50
10-IL-6	IL	5	3.80	2.00	14	4.07	2.00	0.71
10-IL-7	IL	9	3.44	1.67	2	2.50	1.00	1.00
10-IL-8	IL	14	2.29	1.00	6	3.33	1.00	0.52
10-Il-9	IL	4	4.00	2.00	10	4.00	2.00	0.76
10-IL-10	IL	11	3.00	1.09	4	3.75	1.00	0.47

Study	State	Non-Atrazine Avg.			Atrazine Avg.			Atra. Rate
		# Trts.	Actives	Trips	# Trts.	Actives	Trips	lb/A
10-IL-11	IL	10	4.00	2.00	13	4.00	2.00	1.03
10-IL-12	IL	17	2.53	1.00	6	3.33	1.00	0.52
10-IL-13	IL	4	3.50	2.00	14	4.00	2.00	0.75
10-IL-14	IL	5	3.00	1.00	5	3.60	1.00	0.98
10-Il-15	IL	4	4.25	2.00	4	4.75	2.00	1.08
10-IL-16	IL	9	2.78	1.44	14	3.86	1.43	1.00
10-IL-17	IL	2	3.00	2.00	6	3.50	2.00	0.91
10-IL-18	IL	4	3.75	2.00	4	4.25	2.00	0.79
10-IL-19	IL	3	2.33	2.00	3	3.67	2.00	0.94
10-IL-20	IL	3	3.33	2.00	8	3.50	2.00	0.92
10-Il-21	IL	2	4.00	2.00	8	4.38	2.00	0.69
10-IL-22	IL	4	2.00	1.00	6	3.33	1.00	0.52
10-IN-1	IN	10	2.20	1.50	7	3.29	1.86	1.05
10-IN-2	IN	3	3.33	2.00	4	4.00	2.00	0.61
10-IN-3	IN	7	2.14	1.14	2	3.50	1.00	0.50
10-IN-4	IN	5	3.80	2.00	9	3.67	2.00	1.02
10-IN-5	IN	3	2.33	1.33	8	2.88	1.25	1.21
10-IN-6	IN	4	3.25	1.75	5	3.80	1.60	0.83
10-IN-7	IN	6	2.00	1.00	8	2.75	1.00	0.50
10-IN-8	IN	8	4.25	2.00	8	5.50	2.00	0.64
10-KS-1	KS	11	3.18	1.36	16	3.50	1.38	0.71
10-KS-2	KS	12	2.17	1.50	15	2.93	1.40	1.15
10-KS-3	KS	3	3.00	1.33	6	3.33	1.00	0.52
10-MD-1	MD	7	3.71	1.86	3	3.33	1.33	0.83
10-MD-2	MD	3	3.00	1.67	2	4.50	1.50	0.75
10-MD-3	MD	4	4.00	2.00	5	4.00	2.00	0.78
10-MI-1	MI	11	2.27	1.45	10	3.10	1.50	1.29
10-MI-2	MI	4	3.50	2.00	5	4.00	2.00	0.80
10-MI-3	MI	7	2.86	1.71	18	3.39	1.72	1.08
10-MI-4	MI	2	2.50	2.00	6	2.67	1.33	0.50
10-MN-1	MN	17	2.94	1.76	4	3.75	2.00	0.53
10-MN-2	MN	18	3.11	1.72	4	3.75	1.75	0.63
10-MN-3	MN	12	3.42	1.58	3	3.67	1.00	0.50
10-MN-4	MN	5	2.80	1.20	2	3.50	1.50	1.39
10-MN-5	MN	5	2.40	1.20	3	3.67	1.00	0.50
10-MN-6	MN	17	3.47	1.71	5	3.80	1.80	0.53
10-MO-1	MO	3	3.33	2.00	6	3.67	2.00	0.93
10-MO-2	MO	3	4.00	2.00	12	4.25	1.92	0.91
10-MS-1	MS	3	2.33	1.00	7	3.71	1.43	1.22
10-MS-2	MS	3	2.67	1.00	5	3.20	1.00	1.60
10-NC-1	NC	7	3.57	1.14	5	3.00	1.20	0.99
10-NE-1	NE	4	2.75	1.75	8	3.75	2.00	0.90
10-OH-1	OH	7	2.43	1.57	6	3.17	2.00	1.18
10-OH-2	OH	5	4.60	1.20	9	3.89	1.89	1.45
10-OH-3	OH	9	3.56	1.44	8	2.88	1.25	1.13
10-OH-4	OH	4	4.25	2.00	10	3.80	2.00	0.85
10-OH-5	OH	4	3.75	2.00	7	4.43	2.00	1.08
10-PA-1	PA	7	4.43	2.00	8	5.38	2.00	1.05
10-PA-2	PA	4	3.50	1.50	5	3.80	2.00	0.94
10-PA-3	PA	9	2.67	1.00	6	3.00	1.33	0.98
10-SD-1	SD	2	2.50	1.50	6	3.83	1.83	0.54
10-SD-2	SD	7	2.86	1.14	5	3.40	1.00	0.50
10-SD-3	SD	2	3.00	2.00	6	3.50	2.00	0.50
10-SD-4	SD	5	3.00	1.20	2	3.50	1.50	0.64

Study	State	Non-Atrazine Avg.			Atrazine Avg.			Atra.
		# Trts.	Actives	Trips	# Trts.	Actives	Trips	Rate
								lb/A
10-SD-5	SD	6	2.83	1.17	6	3.33	1.00	0.50
10-SD-6	SD	8	3.25	1.13	5	3.00	1.00	0.89
10-SD-7	SD	4	2.75	2.00	4	3.75	2.00	0.83
10-SD-8	SD	3	4.00	2.00	3	3.67	2.00	0.59
10-SD-9	SD	5	3.40	1.80	10	3.10	1.40	0.79
10-SD-10	SD	5	3.40	1.80	10	3.10	1.40	0.79
10-SD-11	SD	5	3.40	1.80	10	3.10	1.40	0.79
10-TX-1	TX	3	2.67	1.33	6	3.83	1.67	1.01
10-WI-1	WI	6	3.17	1.33	8	3.25	1.00	1.00
10-WI-2	WI	9	3.33	1.11	3	3.67	1.00	0.50
10-WI-3	WI	8	2.88	2.00	9	3.44	2.00	0.76
10-WI-4	WI	8	2.63	1.12	9	3.33	1.22	0.54
Average			**3.07**	**1.57**		**3.63**	**1.55**	**0.83**

Table 6. Statistical analysis of crop yields for 2006-2010.

	Tillage Types			
Corn	All Corn	No-Till	Reduced Tillage	Conventional Tillage
Mean Yield Increase With Atrazine	3.30%	6.73%	2.70%	3.12%
Standard Deviation	6.91	9.19	5.55	7.12
Standard Error Of Mean	0.33	1.43	0.44	0.45
Upper 95% Confidence Interval	3.94%	9.63%	3.57%	4.01%
Lower 95% Confidence Interval	2.66%	3.83%	1.82%	2.23%
Wilcoxon Signed-Rank Significant Probabilities Yield Increase With Atrazine	> 0.0%, >1.75%. Not Significant >2%	>3%	>1%	>1%
t-test Significant Probabilities Yield Increase With Atrazine	>0.0%, >1.75%, >2.0%	>4%	>1%	>2%
Sorghum	All Sorghum			
Sorghum All Tillage Types				
Mean Yield Increase With Atrazine	6.42%			
Standard Deviation	6.83			
Standard Error Of Mean	1.97			
Upper 95% Confidence Interval	10.75%			
Lower 95% Confidence Interval	2.08%			
Wilcoxon Signed-Rank Significant Probabilities Yield Increase With Atrazine	>2.0%			
t-test Significant Probabilities Yield Increase With Atrazine	>2.0%			

Table 7. Summary of three site-years of data from Minnesota Atrazine BMP Rate studies. Atrazine at 0.5 lb/A active was added to label rates of the postemergence atrazine alternatives Callisto (mesotrione), Hornet (flumetsulam + chlopyralid) and Clarity (dicamba). All treatments received s-metolachlor preemergence at 1 lb/A active.

Treatment	Corn Yield bu/A				
	Studies				Bu/A increase with Atrazine
	7-MN-10	8-MN-5	8-MN-7	3yr Ave.	
Callisto	124	187	132	147.7	
Callisto + Atrazine	159	227	140	175.3	27.6
Hornet	109	194	123	142.0	
Hornet + Atrazine	142	216	159	172.3	30.3
Clarity	97	209	142	149.3	
Clarity + Atrazine	120	230	160	170.0	20.7

Table 8. Average per acre costs of atrazine and 25 alternative broadleaf herbicides in corn. Prices are from 2012 Guide for Weed Management, University of Nebraska Extension.

Herbicide	Typical Labeled Rate lb active/A	$ Cost/ lb active	Average $ Cost/acre
Atrazine	**1.0**	**3.00**	**3.00**
Aim	0.008	520.0	4.16
Banvel	0.5	12.00	6.00
Basagran	1.0	28.75	28.75
Basis	0.015	336.00	5.04
Beacon	0.036	560.00	20.16
Buctril	0.5	40.00	20.00
Callisto post	0.078	171.25	13.36
Callisto pre	0.19	171.25	32.54
Capreno	0.08	239.13	19.13
Clarity	0.5	24.25	12.13
2,4-D	0.5	4.50	2.25
Distinct	0.26	58.00	15.08
Hornet	0.2	98.08	19.61
Ignite	0.4	26.07	10.48
Impact	0.164	1051.00	17.24
Laudis	0.082	204.57	16.77
Northstar	0.15	84.05	12.61
Option	0.033	525.00	17.33
Permit	0.05	469.33	23.47
Python	0.048	266.00	12.77
Require Q	0.15	94.59	14.00
Resolve Q	0.175	621.00	10.87
Resource	0.04	267.00	10.68
Roundup	0.75	7.00	5.25
Yukon	0.328	58.51	19.20
Average Non-atrazine			**14.75**

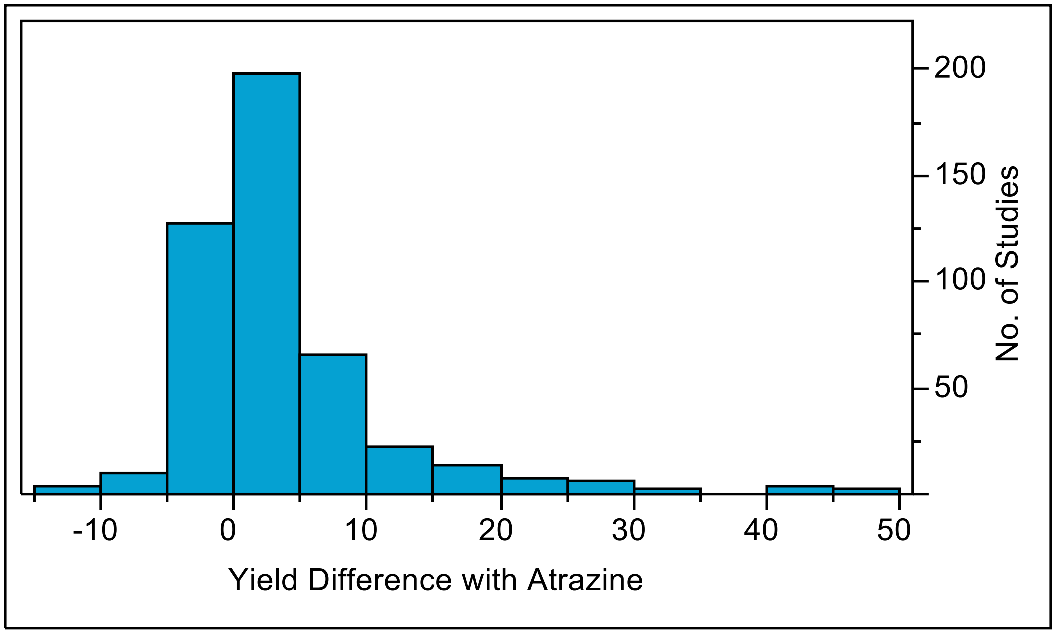

Figure 1. Distribution of corn yields as percent difference for yields with atrazine versus yields without atrazine, 2006-2010.

Studies Cited

Citations followed by (W) are from university weed science websites. Citations followed by (S) are from the Syngenta database.

Corn Studies 2006

6-AR-1 Evaluate Lumax and Lexar in glyphosate tolerant corn systems with COI; Lexar and Lumax use in Arkansas corn production. Univ. of Arkansas. Keiser, AR. (S)

6-AR-2 Rimsulfuron use in Roundup Ready corn. Univ. of Arkansas. Keiser, AR. (S)

6-AR-3 Stout herbicide tank mixtures for corn weed control. Univ. of Arkansas. Keiser, AR. (S)

6-AR-4 Late season morningglory control in field corn. Univ. of Arkansas. Keiser, AR. (S)

6-AR-5 Evaluation of AE0172747 for Arkansas corn production. Univ. of Arkansas. Keiser, AR. (S)

6-DE-1 Comparison of HPPD-inhibiting herbicides for corn. Univ. of Delaware. Georgetown, DE. (S)

6-DE-2 Herbicide programs for conventional tillage Roundup Ready corn. Univ. of Delaware. Georgetown, DE. (S)

6-DE-3 Post products in non-Roundup Ready field corn. Univ. of Delaware. Georgetown, DE. (S)

6-DE-4 Herbicide resistance management in Roundup Ready corn. Univ. of Delaware. Georgetown, DE. (S)

6-IA-1 Preemergence applied Sequence, Lumax, and Bicep Lite II Magnum and postemergence applied Touchdown Total in no tillage corn. Nashua, IA, 2006. Iowa State Univ. (W)

6-IA-2Preemergence applied Radius, Atrazine, Balance Pro and Lumax. Postemergence applied Liberty, Callisto, Option, and Roundup WeatherMAX in corn, Ames, IA, 2006. Iowa State Univ. (W)

6-IA-3 Two pass corn herbicide programs; Preemergence applied Radius, Atrazine, Balance Pro and others followed by Roundup WeatherMAX in corn, Ames, IA, 2006. Iowa State Univ. (W)

6-IA-4 Preemergence applied Dual II Magnum followed by postemergence applications of GWN-3039, Permit, Atrazine, Callisto and Hornet in corn, Ames, IA, 2006. Iowa State Univ. (W)

6-IA-5 Preemergence applied Lexar, Lumax, Harness Xtra and postemergence Lumax, Lexar, Touchdown Total, Roundup WeatherMAX, Resolve and Expert in corn, Ames, IA, 2006. Iowa State Univ. (W)

6-IL-1 Lumax and Lexar Weed Control Systems in Glyphosate-Resistant Corn. AS-100. Univ. of Illinois. Urbana, IL. (W)

6-IL-2 Weed Control Systems in Glyphosate-Resistant Corn. SW1500W. Univ. of Illinois. Urbana, IL. (W)

6-IL-3 Weed Control Systems in Glyphosate-Resistant Corn. E2/E3. Univ. of Illinois. DeKalb, IL. (W)

6-IL-4 Weed Control Systems in Glyphosate-Resistant Corn. 2404. Univ. of Illinois. Brownstown, IL. (W)

6-IL-5 Sequence, Lexar and Touchdown Combinations in No-till Glyphosate-Resistant Corn. Southern Illinois Univ. Belleville, IL. (W)

6-IL-6 Weed Management in Liberty Link plus Roundup Ready Corn – 1. Southern Illinois Univ. Belleville, IL. (W)

6-IL-7 Weed Management in Liberty Link plus Roundup Ready Corn – 2. Southern Illinois Univ. Belleville, IL. (W)

6-IL-8 Dual II Magnum and Lumax: Weed Control systems in glyphosate resistant corn. Univ. of Illinois, Urbana, IL. (S)

6-IL-9 Lumax and Touchdown Total: Weed control systems in glyphosate resistant corn. Univ. of Illinois, Perry, IL. (S)

6-KS-1 Lexar and Touchdown Total: Nonglyphosate tolerant vs. glyphosate tolerant corn. Kansas State Univ. Hesston Expt. Field. KS. (S)

6-KY-1 Gramoxone Inteon no-till corn burndown. Univ. of Kentucky. Spindletop, KY. (S)

6-LA-1 Evaluation of Sequence and Lexar in Roundup Ready corn. Louisiana State Univ. NE Research Station, LA. (S)

6-MD-1 Evaluate Lumax and Lexar in glyphosate tolerant corn systems with COI. Univ. of Maryland. Queenstown, MD. (S)

6-MD-2 Callisto and Roundup Weathermax: Early post programs for conventional corn. Univ. of Maryland. Wye, MD. (S)

6-MD-3 Lumax and Callisto postemergence in conventional corn. Univ. of Maryland. Laurel, MD. (S)

6-MN-1 2006 Corn Herbicide Evaluation. Univ. of Minnesota. (W)

6-MN-2 2006 Corn Herbicide Evaluation – Lamberton. Univ. of Minnesota. (W)

6-MN-3 2006 Corn Herbicide Evaluation – Rochester. Univ. of Minnesota. (W)

6-MN-4 2006 Corn Herbicide Evaluation – Waseca. Common Cocklebur Site. Univ. of Minnesota. (W)

6-MN-5 2006 Corn Herbicide Evaluation – Waseca. Common Ragweed Site. Univ. of Minnesota. (W)

6-MN-6 2006 Corn Herbicide Evaluation – Waseca. Tall Waterhemp Site. Univ. of Minnesota. (W)

6-MN-7 Evaluation of Callisto® based herbicide programs in conventional, Liberty Link® and RR®/GT for weed control in field corn at Rochester, MN in 2006. Univ. of Minnesota. (W)

6-MN-8 Weed control in Roundup Ready or Liberty-Link corn systems at Lamberton, MN in 2006. Univ. of Minnesota. (W)

6-MN-9 Weed control with Define, Option, AE 0172747, and Liberty in Liberty Link corn at Lamberton, MN in 2006. Univ. of Minnesota. (W)

6-MN-10 Evaluation of weed management systems in field corn at Rochester, MN in 2006. Univ. of Minnesota. (W)

6-MO-1 Non GT vs. GT corn herbicide programs. Univ. of Missouri. Bradford, MO. (S)

6-MO-2 Evaluation of programs for the management of resistant waterhemp in corn. Univ. of Missouri. Greenly, MO. (S)

6-MO-3 Sequence: Evaluation of preemerge vs. postemergence applications for weed control in corn – high ATZ. Univ. of Missouri. Delta Center, MO. (S)

6-MO-4 Evaluation of 2-pass Programs for use in Corn. Univ. of Missouri. Bradford, MO. (W)

6-MO-5 Fall Panicum Control in Corn with 2-pass Programs from Bayer. Univ. of Missouri. Greenley, MO. (W)

6-MO-6 Evaluation of Stout Programs and Tank-mixes for Corn. Univ. of Missouri. Bradford, MO. (W)

6-MS-1 Sales support: Evaluation of Sequence and Lexar in RR corn. Mississippi State Univ. Northeast MSREC, MS. (S)

6-MS-2 Sales support: Evaluation of Sequence and Lexar in RR corn. Mississippi State Univ. Pontotoc, MS. (S)

6-MS-3 Gramoxone Inteon no-till corn burndown university COI program – Southern Version. Mississippi State Univ. DREC. MS. (S)

6-NY-1 Preemergence use of Lumax versus early, mid, and late timings on corn. Cornell Univ. Aurora, NY. (S)

6-OH-1 Mespert efficacy and yield in glyphosate tolerant corn. OARDC Western Research Station. Ohio State Univ. OH. (S)

6-OH-2 Evaluate Lexar and Lumax in glyphosate tolerant corn systems. OARDC Western Research Station. Ohio State Univ. OH. (S)

6-OH-3 Evaluation of Lumax and Lexar in glyphosate tolerant corn systems. Ohio State Univ. Columbus, OH. (S)

6-OH-4 Sequence, Lexar, and Touchdown Total combinations in no-till glyphosate resistant corn. Ohio State Univ. Columbus, OH. (S)

6-SD-1 2006 Weed Control Programs in Corn. Southeast Research Farm. South Dakota State Univ. Brookings, SD. (W)

6-SD-2 2006 Weed Control in Corn with Stout Tank-Mixtures. Southeast Research Farm. South Dakota State Univ. Brookings, SD. (W)

6-TN-1 Sequence: Evaluation of preemergence vs. postemergence applications for weed control in no-till corn – high ATZ. Univ. of Tennessee. Knoxville, TN. (S)

6-TN-2 Evaluate Lumax and Lexar in glyphosate tolerant corn systems with COI. Univ. of Tennessee. Knoxville, TN. (S)

6-TN-3 Mespert efficacy and yield in glyphosate tolerant corn. Univ. of Tennessee. Knoxville, TN. (S)

6-TX-1 Lumax and Princep on field corn. Texas A&M Univ. Bushland, TX. (S)

6-WI-1 Evaluate Lumax and Lexar in glyphosate tolerant corn systems with COI. Univ. of Wisconsin. Arlington, WI. (S)

2007

7-AR-1 Weed control and yield with A15189 at universities. Univ. of Arkansas. SE Center, AR. (S)

7-AR-2 FMC early post programs. Univ. of Arkansas. SE Center, AR. (S)

7-AR-3 One shot corn programs. Univ. of Arkansas. Rohwer, AR. (S)

7-AR-4 Total post program for corn. Univ. of Arkansas. Rohwer, AR. (S)

7-AR-5 Laudis weed control as part of Bayer corn portfolio. Univ. of Arkansas. Rohwer, AR. (S)

7-AR-6 Lexar and Bicep II Magnum in corn. Univ. of Arkansas. Keiser, AR. (S)

7-AR-7 Evaluation of Laudis weed control programs in corn. Univ. of Arkansas. Keiser, AR. (S)

7-AR-8 Evaluation of Impact and Sequence in corn. Univ. of Arkansas. Keiser, AR. (S)

7-AR-9 Lumax and Lexar: One shot corn program. Univ. of Arkansas. Fayetteville, AR. (S)

7-AR-10 Lumax and Lexar: One shot corn program. Univ. of Arkansas. Keiser, AR. (S)

7-AR-11 Lumax and Lexar: One shot corn program. Univ. of Arkansas. Rohwer, AR. (S)

7-IA-1 Comparison of herbicides applied preemergence and postemergence in corn. Iowa State Univ. Ames, IA. (W)

7-IA-2 Preemergence applied Lumax, Harness Xtra, SureStart and postemergence applied Touchdown Total, Roundup Original MAX, and Durango in corn. Iowa State Univ. Ames, IA. (W)

7-IA-3 Postemergence applications of Permit, Atrazine, Impact, Callisto, Laudis, Sencor, and Yukon in corn. Iowa State Univ. Ames, IA. (W)

7-IA-4 Preemergence Harness Xtra, Dual II Magnum, SureStart, Lumax and postemergence Halex GT, Roundup Original MAX, and Touchdown Total in corn. Iowa State Univ. Ames, IA. (W)

7-IA-5 Postemergence applied Laudis, Liberty, Callisto, Impact, and Atrazine in various tank-mixtures in corn. Iowa State Univ. Ames, IA. (W)

7-IA-6 Various two pass and one pass herbicide programs in corn. Iowa State Univ. Nashua, IA. (W)

7-IL-1 Roundup-Ready Corn 2 Systems for Weed Control. AS-200. Univ. of Illinois. Urbana, IL. (W)

7-IL-2 Postemergence Weed Control in Roundup-Ready Corn. AS-200. Univ. of Illinois. Urbana, IL. (W)

7-IL-3 Sequential Programs for Weed Control in Glyphosate-Resistant Corn. As-400. Univ. of Illinois. Urbana, IL. (W)

7-IL-4 Halex GT for Weed Control and Yield in Glyphosate-Resistant Corn. As-400. Univ. of Illinois. Urbana, IL. (W)

7-IL-5 Rimsulfuron and Isoxaflutole for Weed Control in RR and LL Corn. C-500. Univ. of Illinois. Urbana, IL. (W)

7-IL-6 Metribuzin and other options for weed control in glyphosate-resistant no-till corn. N-200. Univ. of Illinois. Urbana, IL. (W)

7-IL-7 Weed Control Systems in Roundup-Ready Corn. SW1500W. Univ. of Illinois. DeKalb, IL. (W)

7-IL-8 Sequential Programs for Weed Control in Glyphosate and Glufosinate-Resistant Corn. SW1600. Univ. of Illinois. DeKalb, IL. (W)

7-IL-9 Weed Control Systems in Glyphosate-Resistant Corn. 800. Univ. of Illinois. Brownstown, IL. (W)

7-IL-10 Weed Control Systems in Corn. 800. Univ. of Illinois. Brownstown, IL. (W)

7-IL-11 Weed Control Systems in Glyphosate-Resistant Corn. 2404. Univ. of Illinois. Perry, IL. (W)

7-IL-12 Laudis Tank-Mixtures in Liberty Link Corn. Southern Illinois Univ. Belleville, IL. (W)

7-IL-13 Permit Postemergence Combinations. Southern Illinois Univ. Belleville, IL. (W)

7-IL-14 Laudis Programs. Southern Illinois Univ. Belleville, IL. (W)

7-IL-15 Rimsulfuron plus Isoxaflutole Foundation in Corn. Southern Illinois Univ. Belleville, IL. (W)

7-IL-16 Evaluation of Halex GT and Competitive Standards. Southern Illinois Univ. Belleville, IL. (W)

7-IL-17 Impact Sequential Programs. Southern Illinois Univ. Belleville, IL. (W)

7-IL-18 Roundup Ready Corn Program Comparison – Monsanto. Southern Illinois Univ. Belleville, IL. (W)

7-IL-19 Gramoxone Inteon: Programs for control of glyphosate resistant weeds in RR corn. Southern Illinois Univ. Murphysboro, IL. (S)

7-IL-20 Evaluate the effect of weed size and herbicide rate on A15189G. Southern Illinois Univ. Belleville, IL. (S)

7-IL-21 Weed control in glyphosate tolerant corn. Western Illinois Univ. Macomb, IL. (S)

7-IL-22 Program approaches with new Isoxadifen blends. Western Illinois Univ. WIU Ag Field Lab. Macomb, IL. (S)

7-IL-23 Weed control in corn with Liberty. Western Illinois Univ. WIU Ag Field Lab. Macomb, IL. (S)

7-IL-24 Impact sequential programs and HPPD comparisons. Western Illinois Univ. WIU Ag Field Lab. Macomb, IL. (S)

7-KS-1 Syngenta corn non-glyphosate programs and Syngenta corn glyphosate programs. Kansas State Univ. Ashland, KS. (S)

7-KS-2 Weed control in RR corn with Lumax and Lexar. Kansas State Univ. Rossville, KS. (S)

7-KS-3 Demonstrate efficacy of Halex GT. Kansas State Univ. Tribune, KS. (S)

7-KY-1 Sales support: Weed control and yield with Syngenta programs including A15189 in corn. Univ. of Kentucky. Spindletop, KY. (S)

7-KY-2 Evaluation of A15189 formulations for crop safety and weed control. Univ. of Kentucky. Spindletop, KY. (S)

7-LA-1 Weed control and yield with A15189 at universities. Louisiana State Univ. Dean Lee Research Station. LA. (S)

7-LA-2 Weed control and corn yield with A15189 at universities. Louisiana State Univ. LA. (S)

7-MD-1 Weed control and corn yield with A15189 at universities. Univ. of Maryland. Wye, MD. (S)
7-MD-2 Lumax and Bicep II Magnum in Liberty Link corn. Univ. of Maryland. Wye, MD. (S)

7-MD-3 Roundup Weathermax, Callisto, and Laudis for postemergence control of glyphosate resistant lambsquarters. Univ. of Maryland. Wye, MD. (S)

7-MI-1 Weed control and corn yield with A15189. Michigan State Univ. East Lansing, MI. (S)

7-MN-1 2007 Corn Herbicide Evaluation – Lamberton. Univ. of Minnesota. (W)

7-MN-2 2007 Corn Herbicide Evaluation – Rochester. Univ. of Minnesota. (W)

7-MN-3 2007 Corn Herbicide Evaluation – Waseca. Common cocklebur Site. Univ. of Minnesota. (W)

7-MN-4 2007 Corn Herbicide Evaluation – Waseca. Common ragweed Site. Univ. of Minnesota. (W)

7-MN-5 2007 Corn Herbicide Evaluation – Waseca. Giant ragweed Site. Univ. of Minnesota. (W)

7-MN-6 2007 Corn Herbicide Evaluation – Waseca. Tall waterhemp Site. Univ. of Minnesota. (W)

7-MN-7 Annual weed control with Lumax, Callisto, and Halex GT in glyphosate resistant corn at Lamberton, MN in 2007. Univ. of Minnesota. (W)

7-MN-8 Compare and contrast weed control differences with Callisto, Impact, and Laudis herbicides in a Liberty Link field corn program at Rochester, MN, in 2007. Univ. of Minnesota. (W)

7-MN-9 Comparison of the weed control performance of Laudis to other glyphosate, Liberty, and conventional herbicide programs in field corn at Rochester, MN, in 2007. University of Minnesota. (W)

7-MN-10 Evaluation of the impact of BMP rates of atrazine tank mixed with several broadleaf herbicides in field corn at Rochester, MN, in 2007. University of Minnesota. (W)

7-MN-11 Evaluation of the performance of Halex GT compared to other glyphosate and conventional herbicide programs in field corn at Rochester, MN, in 2007. University of Minnesota. (W)

7-MN-12 Evaluation of weed management systems in field corn at Rochester, MN, in 2007. University of Minnesota. (W)

7-MN-13 Herbicide performance in corn at Lamberton, MN, in 2007. University of Minnesota. (W)

7-MN-14 Weed control with Steadfast, Stout, and Resolve tank-mixed with Impact, Roundup Original Max or Liberty in corn at Lamberton, MN, in 2007. University of Minnesota. (W)

7-MO-1 Syngenta corn programs. University of Missouri. Bradford REC, MO. (S)

7-MO-2 Callisto vs. HPPDs for weed control in field corn. University of Missouri. Bradford, MO. (S)

7-MO-3 Bicep II Magnum and Callisto in corn: Evaluation of HPPD – inhibiting herbicides. Univ. of Missouri. Greenly, MO. (S)

7-MO-4 Laudis + Liberty Programs in Liberty Link Corn. Univ. of Missouri. Columbia, MO. (W)

7-MO-5 Evaluation of 1-pass post programs compared to other programs in RR corn. Bradford Res. Farm. Columbia, MO. (S)

7-MO-6 A15189 weed control and yield. Univ. of Missouri. Delta Station, MO. (S)

7-MO-7 Program Approaches with new Steadfast, Stout, and Resolve Blends. University of Missouri. Columbia, MO. (W)

7-MO-8 Roundup Ready Corn 2 System Comparisons. Univ. of Missouri. Weston, MO. (W)

7-MO-9 Evaluation of Laudis Programs for Use in Corn. Univ. of Missouri. Columbia, MO. (W)

7-MS-1 Halex GT: University trial to gain COI recommendations. Mississippi State Univ. Delta Research Center, MS. (S)

7-MS-2 Evaluation of Lexar and Camix in RR corn. Mississippi State Univ. Pontotoc, MS. (S)

7-NE-1 Evaluation of Impact. Univ. of Nebraska. Havelock, NE. (W)

7-NE-2 Preemergence and Postemergence Herbicides for Weed Control in Liberty Link Corn – 2007. Univ. of Nebraska. North Platte, NE. (W)

7-NE-3 Permit and tank mix partners. Univ. of Nebraska. Havelock, NE. (W)

7-NE-4 Glyphosate Resistant Corn Herbicide Programs. Univ. of Nebraska. Havelock, NE. (W)

7-NE-5 Weed Control Programs for Irrigated Corn in Western Nebraska during the 2007 Growing Season. Univ. of Nebraska. Scottsbluff, NE. (W)

7-NE-6 Controlling Weeds in Irrigated Roundup Ready® Corn at Scottsbluff, Nebraska During the 2007 Growing Season. Univ. of Nebraska. Scottsbluff, NE. (W)

7-NE-7 2007 Balance / Liberty / Option / Radius / Corn / Performance Weed Control. Univ. of Nebraska. Concord, NE. (W)

7-NE-8 2007 Laudis / Liberty / Corn / Performance Weed Control. Univ. of Nebraska. Concord, NE. (W)

7-NE-9 2007 Weed Control and Corn Yield with Halex GT (A15189). Univ. of Nebraska. Concord, NE. (W)

7-NE-10Callisto, Lexar, and Lumax: Corn herbicide demonstration trial. Univ. of Nebraska. Clay Center, NE. (S)

7-NY-1 Weed control and corn yield with A15189 at universities. Cornell Univ. Valatie, NY. (S)

7-OH-1 Evaluate the effect of weed size and herbicide rate on A15189G performance in corn. OSU-OARDC. OH. (S)

7-OH-2 Evaluation of A15189 formulation for crop safety and weed control. OSU-OARDC Western Research Farm. OH. (S)

7-SD-1 2007 Laudis Programs in Corn. Southeast Research Station. South Dakota State Univ. (W)

7-SD-2 2007 Weed Control with Laudis in Corn. Northeast Research Station. South Dakota State Univ. Brookings, SD. (W)

7-SD-3 2007 Weed Control and Corn Yield with Halex GT. Northeast Research Station. South Dakota State Univ. (W)

7-SD-4 2007 Weed Control in Conventional and RR Corn. Southeast Research Station. South Dakota State Univ. Brookings, SD. (W)

7-SD-5 2007 RR Corn 2 System Comparisons. Southeast Research Station. South Dakota State Univ. Brookings, SD. (W)

7-SD-6 2007 Permit/Postemergence Weed Control Combinations. Southeast Research Station. South Dakota State Univ. Brookings, SD. (W)

7-TN-1 Weed control and corn yield with A15189 at universities. Univ. of Tennessee. Knoxville, TN. (S)

7-TN-2 Weed control and yield with A15189 at universities. Univ. of Tennessee. West Research Center, TN. (S)

7-TN-3 Gramoxone Inteon: Programs for control of glyphosate resistant weeds in RR corn. Univ. of Tennessee. West TN Research Center, TN. (S)

7-TX-1 Lexar, Touchdown Total, and A15189 in Roundup Ready corn. Texas A & M Univ. Burleson County, TX. (S)

7-TX-2 Weed control and corn yield with A15189 at universities: Weed control and yield with Halex GT (A15189). Texas A & M Univ. Bushland, TX. (S)

7-WI-1 Weed control and corn yield with A15189 at universities. Univ. of Wisconsin. Prairie du Sac, WI. (S)

7-WI-2 Halex GT: Compare corn weed control and yields: SCP vs. OM program. Univ. of Wisconsin. Prairie du Sac, WI. (S)

2008

8-AR-1 Halex GT University weed control & yield in glyphosate tolerant corn – Southern Version. Univ. of Arkansas. SE Research Center, AR. (S)

8-AR-2 Laudis, Capreno, Balance Flex, and Corvus weed control in corn. Univ. of Arkansas. Rohwer, AR. (S)

8-AR-3 Total pre program. Univ. of Arkansas. Rohwer, AR. (S)

8-AR-4 Total post program. Univ. of Arkansas. Rohwer, AR. (S)

8-AR-5 Program approaches with Steadfast Q, Resolve Q, and Require Q. Program approaches with Yukon and Permit. Univ. of Arkansas. Rohwer, AR. (S)

8-AR-6 ET combinations & timings for corn weed control. Univ. of Arkansas. Rohwer, AR. (S)

8-AR-7 Laudis, Balance Flex, Capreno and Corvus / All corn / Performance. Univ. of Arkansas. Keiser, AR. (S)

8-AR-8 Corn competitive herbicide foundation trials. Univ. of Arkansas. Keiser, AR. (S)

8-AR-9 One shot corn program. Univ. of Arkansas. Fayetteville, AR. (S)

8-AR-10 One shot corn program. Univ. of Arkansas. Keiser, AR. (S)

8-AR-11 Miscellaneous corn program. Univ. of Arkansas. Keiser, AR. (S)

8-DE-1 Comparison of Impact with other HPPD herbicides applied postemergence. Univ. of Delaware. Georgetown, DE. (S)

8-IA-1 Postemergence applied Callisto, Atrazine, Impact, Laudis, Status, Northstar and Touchdown Total in corn. Iowa State Univ. Ames, IA. (W)

8-IA-2 Two and one-pass programs in corn. Pre applied Lumax, Lexar, SureStart. Post applied Halex, Roundup PowerMAX, Laudis, Status and Impact. Iowa State Univ. Ames, IA. (W)

8-IA-3 Various preemergence followed by postemergence applied herbicide programs in corn. Iowa State Univ. Ames, IA. (W)

8-IA-4 Preemergence applied Rimsulfuron, Isoxaflutole, Atrazine, and Harness Xtra and postemergence applied Roundup PowerMAX in corn. Iowa State Univ. Lewis,IA. (W)

8-IA-5 Preemergence Corvus, Balance Flexx, Atrazine. Postemergence Ignite, Laudis, Capreno and Roundup PowerMAX in corn. Iowa State Univ. Lewis, IA. (W)

8-IA-6 Two and one-pass programs in corn. Pre applied Lumax, Lexar, SureStart. Post applied Halex, Roundup PowerMAX, Laudis, Status and Impact. Iowa State Univ. Nashua, IA. (W)

8-IA-7 Preemergence SureStart, Corvus and, Balance Flexx. Postemergence Durango DMA, Permit, Rimsulfuron, Ignite, Laudis and, Roundup PowerMAX in corn. Iowa State Univ. Nashua, IA. (W)

8-IA-8 Postemergence applied Impact in various tank-mixtures in corn. Iowa State Univ. Nashua, IA. (W)

8-IL-1 Weed Control Systems in Corn. 3105. Univ. of Illinois. Perry, IL. (W)

8-IL-2 Weed Control Systems in Corn. E3. Univ. of Illinois. Brownstown, IL. (W)

8-IL-3 Weed control programs in glyphosate-resistant corn. SW-1500. Univ. of Illinois. DeKalb, IL. (W)

8-IL-4 Isoxadifen Q blends for weed control in glyphosate-resistant corn. C-400. Univ. of Illinois. Urbana, IL. (W)

8-IL-5 Halex GT comparisons for weed control in glyphosate-resistant corn. C-500. Univ. of Illinois. Urbana, IL. (W)

8-IL-6 Monsanto sequential comparisons for weed control in glyphosate-resistant corn. C-500. Univ. of Illinois. Urbana, IL. (W)

8-IL-7 Glyphosate tank-mixtures for weed control in glyphosate-resistant corn. AS-400. Univ. of Illinois. Urbana, IL. (W)

8-IL-8 Sequential programs for morningglory control in glyphosate-resistant corn. AS-100. Univ. of Illinois. Urbana, IL. (W)

8-IL-9 Halex GT Evaluations in Reduced-Till Corn. Southern Illinois Univ. Bellevue, IL. (W)

8-IL-10 Competitive Residual Herbicides in Roundup Ready Corn. Southern Illinois Univ. Belleville, IL. (W)

8-IL-11 Halex GT Comparisons in No-Till Corn. Southern Illinois Univ. Belleville, IL. (W)

8-IL-12 Kixor products for weed control in glyphosate resistant corn. Univ. of Illinois. Dekalb, IL. (S)

8-IL-13 Callisto versus competitor herbicides in corn. Western Illinois Univ. Ag Field Lab. Macomb, IL. (S)

8-IL-14 Weed control in corn with Halex GT. Western Illinois Univ. Ag Field Lab. Macomb, IL. (S)

8-IL-15 Capreno efficacy in RR corn. Western Illinois Univ. Ag Field Lab. Macomb, IL. (S)

8-KS-1 Evaluation of Pre and Post herbicide programs in corn, 2008 Syngenta and AMVAC. Kansas State Univ. Ashland Bottoms, KS. (W)

8-KS-2 Evaluation of new Dupont and Gowan products for weed control in corn, 2008. Kansas State Univ. Ashland Bottoms, KS. (W)

8-KS-3 Evaluation of foundation herbicides in RR corn. Kansas State Univ. Ashland Bottoms, KS. (W)

8-KS-4 Bayer herbicides for weed control in corn, 2008. Kansas State Univ. Ashland Bottoms, KS. (W)

8-KS-5 Halex GT: Weed control and yield in corn. Kansas State Univ. KS. (S)

8-KY-1 Weed control in corn with Lexar and Durango. Univ. of Kentucky. Lexington, KY. (S)

8-KY-2 Lexar and Durango for weed control in corn. Univ. of Kentucky. Lexington, KY. (S)

8-LA-1 Halex GT University weed control & yield in glyphosate tolerant corn – Southern Version. Louisiana State Univ. Northeast Research Station, LA. (S)

8-MD-1 Halex GT University weed control & yield in glyphosate tolerant corn – Northern Version. Univ. of Maryland. Queenstown, MD. (S)

8-MD-2 Utility of Impact in conventional corn systems. Univ. of Maryland. Queenstown, MD. (S)

8-MD-3 Preemergence and postemergence programs for Roundup Ready corn. Univ. of Maryland. Queenstown, MD. (S)

8-MD-4 Utility of BAS800H in conventional corn. Univ. of Maryland. Queenstown, MD. (S)

8-MI-1 Halex GT University weed control & yield in glyphosate tolerant corn – Northern Version. Michigan State Univ. MSU Campus, MI. (S)

8-MI-2 Callisto vs. competitor herbicides in corn. Michigan State Univ. MSU Campus, MI. (S)

8-MN-1 2008-10 Atrazine BMP at Lamberton, MN in 2008. Univ. of Minnesota. (W)

8-MN-2 Annual weed control with Balance Flexx, Capreno, and Corvus in corn at Lamberton, MN in 2008. Univ. of Minnesota. (W)

8-MN-3 Annual weed control with Lumax, Halex GT, Callisto, Impact, Laudis, and Status in corn at Lamberton, MN in 2008. Univ. of Minnesota. (W)

8-MN-4 Annual weed control with soil applied herbicides in Roundup-Ready corn at Lamberton, MN in 2008. Univ. of Minnesota. (W)

8-MN-5 Comparison of the impact of BMP rates of atrazine tank mixed with several broadleaf herbicides in field corn at Rochester, MN, in 2007 and 2008. Univ. of Minnesota. (W)

8-MN-6 Evaluation and comparison of HPPD weed control systems in field corn at Rochester, MN, in 2008. Univ. of Minnesota. (W)

8-MN-7 Evaluation of BMP rates of atrazine tank-mixed with broadleaf herbicides at Lamberton, MN in 2008. Univ. of Minnesota. (W)

8-MN-8 Herbicide performance in corn at Lamberton, MN in 2008. Univ. of Minnesota. (W)

8-MN-9 Weed Management in field corn at Rochester, MN, in 2008. Univ. of Minnesota. (W)

8-MN-10 Halex GT University weed control and yield in glyphosate tolerant corn – North Version. Breitenbach. Univ. of Minnesota. Rochester, MN. (W)

8-MN-11 Halex GT University weed control and yield in glyphosate tolerant corn – North Version. J. Getting. Univ. of Minnesota. Lamberton, MN. (W)

8-MO-1 Callisto vs. competitor herbicides in corn. Univ. of Missouri. Novelty, MO. (S)

8-MO-2 Corvus and Balance Flexx used With and Without Ignite for Weed Control in Corn. Univ. of Missouri. Bradford, MO. (W)

8-MO-3 Evaluation of Capreno Herbicide for Use in Conventional and RR Corn Programs. Univ. of Missouri. Bradford, MO. (W)

8-MO-4 Evaluation of New One- and Two-Pass Corn Herbicide Programs. Univ. of Missouri. Greenley, MO. (W)

8-MO-5 Evaluation of Postemergence Corn Herbicide Options. Univ. of Missouri. Bradford, MO. (W)

8-MO-6 Herbicide Program Approaches with Prequel and other new Product Blends. Univ. of Missouri. Bradford, MO. (W)

8-MO-7 Impact Programs for use in Corn. Univ. of Missouri. Greenley, MO. (W)

8-MS-1 Halex GT for weed control and yield in glyphosate tolerant corn. Mississippi State Univ. MS. (S)

8-MS-2 Halex GT University weed control and yield in glyphosate tolerant corn. Mississippi State Univ. MS. (S)

8-NC-1 Halex GT University weed control and yield in glyphosate tolerant corn – Southern Version. North Carolina State Univ. Central Crops Research Station, NC. (S)

8-NE-1 Weed Control in Corn with Corvus, Balance Flexx, and Laudis During the 2008 Growing Season. Univ. Nebraska. Scottsbluff, NE. (W)

8-NE-2 Common Lambsquarters Control in Roundup Ready® Corn During the 2008 Growing Season. Univ. of Nebraska. Scottsbluff, NE. (W)

8-NE-3 Resistant Weed Management Systems in Corn During the 2008 Growing Season at Scottsbluff, NE. Univ. of Nebraska. Scottsbluff, NE. (W)

8-NE-4 2008 Capreno Corn Efficacy University Programs. Univ. of Nebraska. Northeast Research & Extension Center. Concord, NE. (W)

8-NE-5 2008 Corvus and Balance Flex used with and without Ignite 280 for weed control in corn. Univ. of Nebraska. Northeast Research & Extension Center. Concord, NE. (W)

8-NE-6 2008 Surestart PRE RR-Corn Efficacy Crop Tolerance. Univ. of Nebraska. Northeast Research & Extension Centre. Concord, NE. (W)

8-NE-7 2008 Halex GT University Weed Control & Yield in glyphosate tolerant corn. Univ. of Nebraska. Northeast Research & Extension Center. Concord, NE. (W)

8-NE-8 Corn herbicide programs from Syngenta. Univ. of Nebraska. Clay Center, NE. (S)

8-NY-1 Halex GT University weed control and yield in glyphosate tolerant corn – Northern Version. Cornell Univ. Aurora, NY. (S)

8-NY-2 Halex GT University weed control & yield in glyphosate tolerant corn – Northern Version. Cornell Univ. Valatie, NY. (S)

8-OH-1 Halex GT University weed control and yield in glyphosate tolerant corn. Ohio State Univ. Clarksburg, OH. (S)

8-PA-1 Halex GT University weed control and yield in glyphosate tolerant corn. Penn State Univ. Rock Springs, PA. (S)

8-PA-2 Permit, Unity, and other combinations for Roundup Ready corn. Penn State Univ. Rock Springs, PA. (S)

8-SD-1 2008 Post Impact Comparisons. Southeast Research Farm. South Dakota State Univ. Brookings, SD. (W)

8-SD-2 2008 Corn Competitive Herbicide Foundation Trials. Southeast Research Farm. South Dakota State Univ. Brookings, SD. (W)

8-SD-3 Halex GT Univ. weed control and yield in glyphosate tolerant corn. South Dakota State Univ. SD. Brookings, SD. (W)

8-TN-1 Halex GT University weed control and yield in glyphosate tolerant corn. Univ. of Tennessee. Knoxville, TN. (S)

8-TX-1 Halex GT University weed control & yield in glyphosate tolerant corn – Southern Version. Texas A & M Univ. College Station, TX. (S)

8-TX-2 Halex GT University weed control & yield in glyphosate tolerant corn – Southern Version. Texas A & M Univ. Bushland Station, TX. (S)

8-WI-1 Halex GT University weed control & yield in glyphosate tolerant corn – North Version. Univ. of Wisconsin. Arlington, WI. (S)

8-WI-2 Weed control programs in corn for giant ragweed and common lambsquarters. Univ. of Wisconsin. Arlington, WI. (S)

2009

9-AR-1 Mesotrione plus atrazine for crop tolerance and weed control at universities. Univ. of Arkansas, SE Research and Extension Center, AR. (S)

9-AR-2 Balance Flexx, Corvus, Capreno, and Laudis corn performance. Univ. of Arkansas, Keiser, AR. (S)

9-AR-3 Samson corn 2009. Univ. of Arkansas, Keiser, AR. (S)

9-AR-4 One shot corn program. Univ. of Arkansas, Keiser, AR. (S)

9-AR-5 Weed control programs in corn. Univ. of Arkansas, Keiser, AR. (S)

9-AR-6 Weed control programs in corn. Univ. of Arkansas, Fayetteville, AR. (S)

9-AR-7 Efficacy of Balance Flexx, Corvus, Capreno, and Laudis in a corn program. Univ. of Arkansas, Rohwer, AR. (S)

9-AR-8 Authority MTZ & Atrazine in Liberty Link corn. Univ. of Arkansas, Rohwer, AR. (S)

9-AR-9 Kixor weed control programs. Univ. of Arkansas, Rohwer, AR. (S)

9-AR-10 Selectivity and efficacy of NIC-IT in a corn program. Univ. of Arkansas, Rohwer, AR. (S)

9-IA-1Corvus, Balance Flex, Lumax, Integrity, SureStart and, Degree Extra applied preemergence in corn and Capreno, Ignite, Laudis, Halex GT, Touchdown Total, Roundup PowerMax, Durango DMA and Steadfast Q applied postemergence, Nashua, IA, 2009. Iowa State Univ. (W)

9-IA-2 Capreno and Laudis programs in corn, Lewis, IA. 2009. Iowa State Univ. (W)

9-IA-3 Halex GT two and one-pass programs in corn compared with Corvus, Capreno, Ignite, SureStart and Roundup PowerMax, Ames, IA, 2009. Iowa State Univ. (W)

9-IA-4 Preemergence applied Lexar, Lumax, Corvus, Balance Flex, Integrity, SureStart, and Harness Xtra and postemergence applied Touchdown Total, SureStart plus Durango DMA, Durango DMA and Roundup PowerMax in corn, Ames, IA. 2009. Iowa State Univ. (W)

9-IL-1 Weed control systems in RR/LL corn. Perry, IL. Univ. of Illinois. (W)

9-IL-2 Postemergence and residual herbicide systems for weed control in RR/LL corn. Dekalb, IL. Univ. of Illinois. (W)

9-IL-3 Bayer herbicide combinations for weed control in RR/LL corn. Dekalb, IL. Univ. of Illinois. (W)

9-IL-4 Weed control systems in RR/LL corn. Dekalb, IL. Univ. of Illinois. (W)

9-IL-5 Postemergence and residual herbicide systems for weed control in RR/LL corn. Urbana, IL. Univ. of Illinois. (W)

9-IL-6 Weed control systems in RR/LL corn. Urbana, IL Univ. of Illinois. (W)

9-IL-7 Weed control systems with Kixor Technology in RR/LL corn. Urbana, IL. Univ. of Illinois. (W)

9-IL-8 Preemergence herbicides for weed control in RR/LL corn. Urbana, IL. Univ. of Illinois. (W)

9-IL-9 Capreno application timing- site 2. Belleville Res. Center. Southern Illinois Univ., Carbondale, IL. (W)

9-IL-10 Capreno application timing – site 1. Belleville Res. Center. Southern Illinois Univ., Carbondale, IL. (W)

9-IL-11 Residual corn herbicide program comparison. Belleville Res. Center. Southern Illinois Univ., Carbondale, IL. (W)

9-IL-12 Kixor programs in corn. Belleville Res. Center. Southern Illinois Univ., Carbondale, IL. (W)

9-IL-13 Bayer corn programs with Capreno and Laudis. Western Illinois Univ., Macomb, IL. (W)

9-IL-14 Weed control in corn with Corvus, Balance Flex, Capreno, Ignite, and Laudis. Western Illinois Univ., Macomb, IL. (W)

9-IL-15 Integrity demonstration – full rates PPI and PRE. Western Illinois Univ., Macomb, IL. (W)

9-IL-16 Integrity demonstration – reduced rates. Western Illinois University, Macomb, IL. (W)

9-IN-1 Preemergence weed control in corn with full season rates. Throckmorton PAC. Purdue Univ., West Lafayette, IN. (W)

9-IN-2 Kixor herbicide formulations in corn. Throckmorton. Purdue Univ., West Lafayette, IN. (W)

9-IN-3 Dimethenamid herbicide efficacy in corn. Throckmorton. Purdue Univ., West Lafayette, IN. (W)

9-IN-4 Compare Halex GT one and two pass programs vs. competitors for season long weed control in GT/LL corn. Throckmorton. Purdue Univ., West Lafayette, IN. (W)

9-IN-5 Capreno and Laudis in corn. Butlerville. Purdue Univ., West Lafayette, IN. (W)

9-KS-1 Callisto Extra: mesotrione plus atrazine premix for crop tolerance and weed control in corn. Kansas State Univ., Manhattan, KS. (S)

9-KS-2 Lumax, Lexar and Sequence for weed control in corn. Kansas State Univ., Custer Island West, KS. (S)

9-KY-1 Evaluation of new mesotrione plus atrazine premix candidate for postemergence weed control and crop tolerance. Univ. of Kentucky, Spindletop, KY. (S)

9-KY-2 No-till corn preemergence and postemergence. Univ. of Kentucky, Lexington, KY. (S)

9-KY-3 Corn postemergence. Univ. of Kentucky, Lexington, KY. (S)

9-MD-1 Mesotrione plus atrazine premix for crop tolerance and weed control in corn. Univ. of Maryland, Queenstown, MD. (S)

9-MD-2 Weed Control in corn with Lexar and Lumax. Univ. of Maryland, Queenstown, MD. (S)

9-MD-3 Kixor programs in conventional corn – medium soils. Univ. of Maryland, Queenstown, MD. (S)

9-MD-4 An evaluation of the Dupont "Q" herbicides for weed control in conventional corn. U. of MD, Queenstown, MD. (S)

9-MD-5 A comparison of weed control systems for no-till corn. Univ. of Maryland, Laurel, MD. (S)

9-MD-6 Kixor programs in conventional corn – coarse soils. Univ. of Maryland, Laurel, MD. (S)

9-MD-7 Impact combinations and comparisons in conventional corn. Univ. of Maryland, Laurel, MD. (S)

9-MD-8 A comparison of selected post programs for conventional corn. Univ. of Maryland, Queenstown, MD. (S)

9-MI-1 Pre followed by post with and without glyphosate, 2009. Michigan State Univ., East Lansing, MI. (W)

9-MI-2 Pre and post weed control comparisons in corn, 2009. Michigan State Univ., East Lansing, MI. (W)

9-MI-3 Weed control with HPPD inhibitors, 2009. Michigan State Univ., East Lansing, MI. (W)

9-MI-4 Weed control with Capreno, Corvus and Balance Flex, 2009. Michigan State Univ., East Lansing, MI. (W)

9-MI-5 Weed control in corn with Halex GT, 2009. Michigan State Univ., East Lansing,MI. (W)

9-MI-6 Postemergence timing in herbicide resistant corn, 2009. Michigan State Univ., East Lansing, MI. (W)

9-MI-7 Weed control program comparisons, 2009. Michigan State Univ., East Lansing, MI. (W)

9-MN-1 Herbicide performance in corn at Morris, MN – 2009. Univ. of Minnesota. (W)

9-MN-2 Herbicide performance in corn at Lamberton, MN in 2009. Univ. of Minnesota. (W)

9-MN-3 Evaluation of rimsulfuron and nicosulfuron programs plus mesotrione for weed control in field corn in 2009. Rochester, MN. Univ. of Minnesota. (W)

9-MN-4 Evaluation of Capreno herbicide programs in field corn in SE Minnesota in 2009. Univ. of Minnesota, St. Paul, MN. (W)

9-MN-5 Evaluation of BMP rates of atrazine tank-mixed with broadleaf herbicides at Lamberton, MN in 2009. Univ. of Minnesota. (W)

9-MN-6 Comparison of the performance of Callisto Xtra premix to Callisto, Laudis, Impact, Status and Halex GT systems for weed control in field corn at Rochester, MN, 2009. Univ. of Minnesota. (W)

9-MN-7 Comparison of the impact of BMP rates of atrazine tank mixed with several broadleaf herbicides in field corn at Rochester, MN, in 2007, 2008, and 2009. Univ. of Minnesota. (W)

9-MN-8 Annual weed control with pre-mixed soil applied herbicides in corn at Lamberton, MN in 2009. Univ. of Minnesota. (W)

9-MN-9 Annual weed control with Corvus, Balance Flex and Capreno in corn at Lamberton, MN in 2009. Univ. of Minnesota. (W)

9-MN-10 2009 Evaluation of weed management systems in field corn. Univ. of Minnesota, St. Paul, MN. (W)

9-MO-1 Samson corn herbicide programs in conventional corn. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-MO-2 Postemergence weed control in corn with Dupont's "Q" products plus mesotrione. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-MO-3 Evaluation of some common 2-pass programs in corn. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-MO-4 Evaluation of new BASF weed control options in corn. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-MO-5 Evaluation of glyphosate tank-mix combinations in Roundup Ready corn. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-MO-6 Evaluation of full-season rates of PRE corn herbicides from Syngenta. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-MO-7 Evaluation of mesotrione plus atrazine premix for crop tolerance and weed control. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-MO-8 Comparison of 1- and 2-pass programs in RR/LL corn. Bradford. Univ. of Missouri, Columbia, MO. (W)

9-NE-12009 SL-950 corn university study on Samson nicosulfuron. Concord, NE. Univ. of Nebraska. (W)

9-NE-2 2009 Mesotrione plus atrazine premix for crop tolerance and weed control at universities. Concord, NE. Univ. of Nebraska. (W)

9-NE-3 2009 Laudis, Capreno/ corn/ adjuvant packages/ efficacy. Concord, NE. Univ. of Nebraska. (W)

9-NE-4 2009 Capreno, Laudis corn programs/ efficacy/ university. Concord, NE. Univ. of Nebraska. (W)

9-NE-5 2009 Corvus, Balance Flex, Capreno, Ignite and, Laudis/ corn/ weed control/ university. Concord, NE. Univ. of Nebraska. (W)

9-NE-6 2009 Kixor/ corn (north)/ weed control programs/ medium soil. Concord, NE. Univ. of Nebraska. (W)

9-NE-7 Corn herbicide standards trial (S0923). Clay Center, NE. Univ. of Nebraska. (W)

9-NE-8 Kixor weed control programs in corn (S0922). Clay Center, NE. Univ. of Nebraska. (W)

9-NE-9 Impact sequential programs and glyphosate formulations (S0917). Clay Center, NE. Univ. of Nebraska. (W)

9-NE-10Laudis and Capreno application timing and tank-mix partners (S0916). Clay Center, NE. Univ. of Nebraska. (W)

9-NE-11Residual activity of postemergence HPPD-inhibitor herbicides (S0914). Clay Center, NE. Univ. of Nebraska. (W)

9-NE-122009 Corn PRE and PRE/POST standards (L0919). Lincoln, NE. Univ. of Nebraska. (W)

9-NE-132009 Bayer herbicide programs in corn (L0919). Lincoln, NE. Univ. of Nebraska. (W)

9-NE-142009 Carfentrazone burndown in corn (L0915). Lincoln, NE. Univ. of Nebraska. (W)

9-NE-152009 Valor SX in corn programs (L0914). Lincoln, NE. Univ. of Nebraska. (W)

9-NE-16Preemergence and postemergence herbicide application for weed control in corn at Scottsbluff, Nebraska during the 2009 growing season. Scottsbluff, NE. Univ. of Nebraska. (W)

9-OH-1 Pre fb Post weed control programs in corn yield trial HP09NARDLL, USA-09-295. Western Branch Big ES. Ohio State Univ., Columbus, OH. (W)

9-OH-2 PRE followed by POST weed control in corn III. Western Branch F-8 E. Ohio State Univ., Columbus, OH. (W)

9-OH-3 PRE fb POST weed control in corn II. Western Branch Big E. Ohio State Univ., Columbus, OH. (W)

9-OH-4 Preemergence weed control in corn with full season rates. Western Branch Big E. Ohio State Univ., Columbus, OH. (W)

9-OH-5 PRE fb POST weed control in corn I DEM-H-2009-US. C9F-02.0. Western Branch F-8 E. Ohio State Univ., Columbus, OH. (W)

9-OH-6 No-till burndown and weed control in corn I VUSA MD68.01, HZEAMXMET0903, BURN-CORN-OH. Western Branch F-9-W. Ohio State Univ., Columbus, OH. (W)

9-OH-7 Evaluation of new mesotrione plus atrazine premix candidate for postemergence weed control and crop tolerance. Ohio State Univ., OSU Western Ag Research Station, OH. (S)

9-OH-8 Evaluation of new mesotrione plus atrazine candidate for postemergence weed control and crop tolerance (2). Ohio State Univ., OSU Western Ag Research Station, OH. (S)

9-SD-1 Mesotrione + atrazine premix (A16907) in corn Southeast Research Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-2 Valor early preplant burndown in corn. Southeast Research Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-3 Mesotrione mixes in corn. Northeast Research Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-4 Herbicide programs with Outlook and Status in RR corn. Southeast Research Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-5 Corvus and Capreno programs in conventional, RR, and LL programs. Brookings Agronomy Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-6 Weed control programs with Sharpen and Integrity. Northeast Research Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-7 Corn herbicide demonstration. Northeast Research Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-8 Corn herbicide demonstration. Brookings Agronomy Farm. South Dakota State Univ., Brookings, SD. (W)

9-SD-9 Corn herbicide demonstration. Southeast research Farm. South Dakota State Univ., Brookings, SD. (W)

9-TN-1 Mesotrione plus atrazine premix for crop tolerance and weed control at universities. Univ. of Tennessee, Milan, TN. (S)

9-TX-1 Mesotrione plus atrazine premix for crop tolerance and weed control at universities. Texas A&M Univ., Bushland, TX. (S)

9-WI-1 Laudis and Northstar postemergence corn herbicide evaluation. Univ. of Wisconsin, Arlington, WI. (S)

2010

10-AR-1 Integrity and Sharpen corn programs. Univ. of Arkansas, Rohwer, AR. (S)

10-AR-2 Weed control programs in corn. Univ. of Arkansas, Fayetteville, AR. (S)

10-AR-3 Preemergence weed control from Resolve, Resolve Q, Accent and Steadfast Q plus dry mesotrione. Univ. of Arkansas, Keiser, AR. (S)

10-AR-4 Weed control programs in corn. Univ. of Arkansas, Keiser, AR. (S)

10-IA-1 Two-pass weed management programs in corn. Preemergence applied Lumax, Lexar, Corvus, Atrazine, Balance Flexx, Integrity, SureStart and Bicep II Magnum. Postemergence applied Touchdown Total, Durango DMA and Halex GT, Nashua, IA, 2010. Iowa State Univ. (W)

10-IA-2 Halex GT, Laudis, SureStart, Durango DMA, Capreno, Status, Roundup PowerMax and Lumax applied postemergence in corn Nashua, IA, 2010. Iowa State Univ. (W)

10-IA-3 Impact applied postemergence with various tank-mix partners in corn, Ames, IA, 2010. Iowa State Univ. (W)

10-IA-4 Halex GT, Laudis, SureStart, Durango DMA, Capreno, Status, Roundup PowerMax and Lumax applied postemergence in corn, Ames, IA, 2010. Iowa State Univ. (W)

10-IA-5 Postemergence applications of Callisto Xtra, Laudis, Impact, Status and Halex GT in corn, Ames, IA, 2010. Iowa State Univ. (W)

10-IA-6 Two-pass weed management programs in corn. Preemergence applied Lumax, Lexar, Corvus, Atrazine, Balance Flexx, Integrity, SureStart and Bicep II Magnum. Postemergence applied Touchdown Total, Durango DMA and Halex GT, Ames, IA, 2010. Iowa State Univ. (W)

1-IL-1 Syngenta postemergence weed control systems in RR/LL corn. Perry, IL. Univ. of Illinois. (W)

1-IL-2 Postemergence weed control systems in RR/LL corn. Perry, IL. Univ. of Illinois. (W)

10-IL-3 Weed control systems in RR/LL corn. Perry, IL. Univ. of Illinois. (W)

10-IL-4 Syngenta postemergence weed control systems in RR/LL corn. Brownstown, IL. Univ. of Illinois. (W)

10-IL-5 Postemergence weed control systems in RR/LL corn. Brownstown, IL. Univ. of Illinois. (W)

10-IL-6 Weed control in RR/LL corn. Brownstown, IL. Univ. of Illinois. (W)

10-IL-7 Bayer weed control systems in RR/LL corn. Dekalb, IL. Univ. of Illinois. (W)

10-IL-8 Postemergence weed control systems in RR/LL corn. Dekalb, IL. Univ. of Illinois. (W)

10-IL-9 Weed control systems in RR/LL corn. Dekalb, IL. Univ. of Illinois. (W)

10-IL-10 Postemergence weed control systems in RR/LL corn. Urbana, IL. Univ. of Illinois. (W)

10-IL-11 Early preplant and sequential herbicide systems for weed control in RR/LL corn. Urbana, IL. Univ. of Illinois. (W)

10-IL-12 HPPD post combos for weed control in RR/LL corn. Urbana, IL. Univ. of Illinois. (W)

10-IL-13 Weed control systems in RR/LL corn. Urbana, IL. Univ. of Illinois. (W)

10-IL-14 Early postemergence herbicide programs in corn. Belleville Res. Center. Southern Illinois Univ. (W)

10-IL-15 DuPont and Dow herbicide programs. Belleville Res. Center. Southern Illinois Univ. (W)

10-IL-16 Syngenta herbicide programs. Belleville Res. Center. Southern Illinois Univ. (W)

10-IL-17 Impact sequential programs in corn. Belleville Res. Center. Southern Illinois Univ. (W)

10-IL-18 Two-pass herbicide treatments in Roundup Ready field corn with Kixor. Western Illinois Univ., Macomb, IL. (S)

10-IL-19 Early season burndown treatments in no-till Roundup Ready field corn. Western Illinois Univ., Macomb, IL. (S)

10-IL-20 Two-pass herbicide treatments in Roundup Ready field corn. Western Illinois Univ., Macomb, IL. (S)

10-IL-21 Compare Dual, Bicep, or Lumax fb Halex GT to competitive two-pass programs. West. Illinois Univ., Macomb, IL. (S)

10-IL-22 Callisto Xtra applied post in GT corn. Western Illinois Univ., Macomb, IL. (S)

10-IN-1 Pre/post herbicide programs for RR corn in Midwest. Throckmorton. Purdue Univ. (W)

10-IN-2 Sharpen as a tank mix partner for Harness and Harness Xtra. Throckmorton. Purdue Univ. (W)

10-IN-3 Postemergence programs for corn. Throckmorton. Purdue, Univ. (W)

10-IN-4 Pre/post herbicide programs for corn. Throckmorton. Purdue Univ. (W)

10-IN-5 Preemergence herbicide programs in corn. Throckmorton. Purdue Univ. (W)

10-IN-6 RR corn – residual foundation control. Throckmorton. Purdue Univ. (W)

10-IN-7 Performance of Impact and glyphosate combinations. Throckmorton. Purdue Univ. (W)

10-IN-8 Burndown systems with corn using Prequel for control of marestail and winter annual grass. SEPAC. Purdue Univ. (W)

10-KS-1 Foundation rates in two-pass programs and Halex GT vs. competitors in total post programs. Kansas State Univ., Manhattan, KS. (S)

10-KS-2 Preemergence corn herbicide program comparisons. Kansas State Univ., Manhattan, KS. (S)

10-KS-3 Callisto Xtra and Durango for weed control in GR corn. Kansas State Univ., Custer Island South, KS. (S)

10-MD-1 Preemergence and postemergence programs for conventional corn with Lumax and Halex GT. Univ. of Maryland, Queenstown, MD. (S)

10-MD-2 Preemergence and postemergence programs for conventional corn. Univ. of Maryland, Laurel, MD. (S)

10-MD-3 Acetochlor and competitive weed control systems in Roundup Ready corn. Univ. of Maryland, Queenstown, MD. (S)

10-MI-1 Regional comparison of corn herbicide systems, 2010. Campus. Michigan State Univ. (W)

10-MI-2 Evaluation of foundation programs, 2010. Campus. Michigan State Univ. (W)

10-MI-3 Weed control programs comparison in corn, 2010. Campus. Michigan State Univ. (W)

10-MI-4 Weed control in corn with HPPD inhibitors, 2010. Campus. Michigan State Univ. (W)

10-MN-1 Herbicide performance in corn at Morris, MN-2010. Univ. of Minnesota. (W)

10-MN-2 Herbicide performance in corn at Lamberton, MN in 2010. Univ. of Minnesota, St. Paul, MN. (W)

10-MN-3 Comparison of weed management programs to Halex GT herbicide in field corn in SE Minnesota in 2010. Univ. of Minnesota. (W)

10-MN-4 Annual weed control with Realm Q tank mixed with Abundit, Ignite, or atrazine in corn at Lamberton, MN in 2010. Univ. of Minnesota. (W)

10-MN-5 Annual weed control with Halex GT, glyphosate + Laudis, glyphosate + Capreno, glyphosate + Status and glyphosate + Surestart in corn at Lamberton, MN in 2010. Univ. of Minnesota. (W)

10-MN-6 2010 Evaluation of weed management systems in field corn. Rochester, MN. Univ. of Minnesota. (W)

10-MO-1 Evaluation of 2-pass Syngenta programs in corn. Bradford. Univ. of Missouri. (W)

10-MO-2 Evaluation of Syngenta's 2-pass programs compared to competitive standards in corn. Bradford. U. of Missouri. (W)

10-MS-1 Callisto-based weed control programs in Mississippi corn. Mississippi State Univ., OREC-Field 13 North, MS. (S)

10-MS-2 Evaluation of Lexar and Halex GT for weed control in corn. Mississippi State Univ., RR Foil Research Center – North Farm, MS. (S)

10-NE-1 Two-pass weed control programs for glyphosate-resistant corn. Univ. of Nebraska, Clay Center, NE. (S)

10-NC-1 Weed control with Realm Q in no-till corn. North Carolina State Univ., Clayton, NC. (S)

10-OH-1 Midwest corn herbicide demonstration. Western Branch F-7. Ohio State Univ. (W)

10-OH-2 Preemergence fb postemergence weed control in corn 3. Western Branch F-7. Ohio State Univ. (W)

10-OH-3 Pre fb post weed control in corn 2. Western Branch F-7. Ohio State Univ. (W)

10-OH-4 Pre fb post weed control in corn 1. Western Branch F-7. Ohio State Univ. (W)

10-OH-5 Early preplant burndown in corn with Valor, V-10233 and Authority MTZ. Western Branch F-9E. Ohio State U. (W)

10-PA-1 Burndown systems using Prequel, Authority MTZ, and other programs in No-till RR/LL corn. Penn State Univ. (W)

10-PA-2 MON 63410 herbicide programs in RR corn. Rock Springs, PA. Penn State Univ. (W)

10-PA-3 Corvus, Balance Flexx, and Capreno herbicide programs in RR/LL corn. Rock Springs, PA. Penn State Univ. (W)

10-SD-1 Two pass programs in corn. South Dakota State Univ., Beresford, SD. (S)

10-SD-2 Total post programs in corn. South Dakota State Univ., Brookings, SD. (S)

10-SD-3 Impact programs in corn. South Dakota State Univ., Southeast Research Farm, SD. (W)

10-SD-4 Weed control with Realm Q. South Dakota State Univ., Northeast Research Farm, SD. (W)

10-SD-5 One-pass post programs in corn. South Dakota State Univ., Southwest Research Farm, SD. (W)

10-SD-6 Corvus, Capreno, and Balance Flexx in corn. South Dakota State Univ., Southeast Research Farm, SD. (W)

10-SD-7 Preplant applications of Valor and Fierce in corn. South Dakota State Univ., Southeast Research Farm, SD. (W)

10-SD-8 Sharpen and Integrity (Verdict) applications in corn. South Dakota State Univ., Southeast Research Farm, SD. (W)

10-SD-9 Corn herbicide demonstration. South Dakota State Univ., Southeast Research Farm, SD. (W)

10-SD-10 Corn herbicide demonstration. South Dakota State Univ., Brookings Agronomy Farm, SD. (W)

10-SD-11 Corn herbicide demonstration. South Dakota State Univ., Northeast Research Farm, SD. (W)

10-TX-1 Syngenta corn weed control study. Texas A&M Univ., TAES Farm, TX. (S)

10-WI-1 Soil-applied herbicide evaluation on field corn. Arlington-452. Univ. of Wisconsin. (W)

10-WI-2 Postemergence herbicide evaluation – atrazine. Arlington. Univ. of Wisconsin. (W)

10-WI-3 Sequential corn herbicide evaluation. Univ. of Wisconsin, Arlington, WI. (S)

10-WI-4 Callisto Xtra: postemergence evaluation on field corn. Univ. of Wisconsin, Arlington, WI. (S]

Sorghum Studies

2007

S7-AR-1 Peak and Permit use in grain sorghum. Univ. of Arkansas. Rohwer, AR. (S)

S7-AR-2 Milo-Pro weed control program with atrazine and Dual. Univ. of Arkansas. Rohwer, AR. (S)

S7-KS-1 Evaluation of mesotrione for crop safety in grain sorghum. Kansas State Univ., Kansas River Valley Station, KS. (S)

S7-KS-2 Evaluate mesotrione for crop safety and weed control in grain sorghum. Kansas State Univ., Ashland, KS. (S)

S7-KS-3 Evaluate mesotrione for crop safety and weed control in grain sorghum in Kansas. Kansas State Univ., Tribune, KS. (S)

S7-KS-4 Lumax and Lexar application timings for crop response and efficacy in grain sorghum. Kansas State Univ., Hays, KS. (S)

2008

S8-KS-1 Weed control in grain sorghum with Lumax and Lexar. Kansas State Univ., Ashland Bottoms, KS. (S)

2009

S9-AR-1 Sharpen-Integrity weed control in sorghum. Univ. of Arkansas, Rohwer, AR. (S)

S9-TX-1 Preemergence herbicide trial featuring Sharpen. Texas A & M Univ., Bush Farm, TX. (S)

S9-TX-2 Preemergence herbicide trial comparing Sharpen to other commonly used herbicides. Texas A & M Univ., Bushland, TX. (S)

2010

S10-NE-1 Utility of atrazine, Lumax, and Lexar for weed control in sorghum. Univ. of Nebraska, Hastings, NE. (S)

S10-SD-1 Huskie in sorghum. South Dakota State Univ., Brookings, SD. (W)