Proceedings of the 69th Annual Meeting of the North Central Weed Science Society

December 1-4, 2014
Minneapolis, MN

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

PROGRAM[1]

General Session

Welcome to Minneapolis. Bev Durgan*; University of Minnesota, St. Paul, MN (98)

Washington Science Policy Update. Lee Van Wychen*; National and Regional Weed Science Societies, Washington, DC (99)

Turfgrass Management for Professional Sports. Larry DiVito*; Minnesota Twins Baseball Club, Minneapolis, MN (100)

NCWSS Presidential Address. JD Green*; University of Kentucky, Lexington, KY (101)

Necrology Report. Joe Armstrong*; Dow AgroSciences, Davenport, IA (102)

Agronomic Crops I (Corn, Sorghum, Cereals)

Enlist Corn Weed Control Systems in Midwest. David C. Ruen*[1], Mike M. Moechnig[2], Eric F. Scherder[3], Kristin Rosenbaum[4], Laura A. Campbell[5], Fikru Haile[6], Leah L. Granke[7], Jeff M. Ellis[8]; [1]Dow AgroSciences, Lanesboro, MN, [2]Dow AgroSciences, Toronto, SD, [3]Dow AgroSciences, Huxley, IA, [4]Field Scientist, Crete, NE, [5]Dow AgroSciences, Carbondale, IL, [6]Dow AgroSciences, Carmel, IN, [7]Dow AgroSciences, Columbus, OH, [8]Dow AgroSciences, Smithville, MO (1)

†Acuron: A new residual herbicide with four active ingredients for broad-spectrum weed control in corn. Mason Adams*[1], Debalin Sarangi[1], Aaron S. Franssen[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Syngenta Crop Protection, Seward, NE (2)

Another ALS-resistant species: Common Chickweed and its Control. Dwight D. Lingenfelter*[1], William Curran[2]; [1]Penn State University, University Park, PA, [2]Penn State, University Park, PA (3)

Popcorn, Sweet Corn and Field Corn Inbred Tolerance to Preemergence and Postemergence Acuron Applications. Tim Trower*[1], Gordon Vail[2], Ryan D. Lins[3], Tom Beckett[2]; [1]Syngenta, Baraboo, WI, [2]Syngenta, Greensboro, NC, [3]Syngenta, Byron, MN (4)

†Sequential Herbicide Evaluation in Glufosinate-Resistant Corn in Wisconsin. Devin J. Hammer*, Rebecca R. Bailey, Thomas R. Butts, Daniel H. Smith, Elizabeth J. Bosak, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (5)

Acuron Herbicide: Burndown and Residual Weed Control in No-Till Corn. Scott E. Cully*[1], Nicholas A. Frederking[1], Thomas H. Beckett[2], Gordon Vail[3]; [1]Syngenta, Marion, IL, [2]Syngenta Crop Protection, Greensboro, NC, [3]Syngenta, Greensboro, NC (6)

Confirmation and Characterization of ALS-inhibitor Resistance in Henbit (*Lamium amplexicaule*). Vijay K. Varanasi*[1], Amar S. Godar[1], Dallas E. Peterson[1], Doug Shoup[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University - Southeast Area Extension Office, Chanute, KS (7)

SYN-A205: A Technical Overview. Scott Payne*[1], Ryan D. Lins[2], Gordon Vail[3], Tom Beckett[3]; [1]Syngenta, Slater, IA, [2]Syngenta, Byron, MN, [3]Syngenta, Greensboro, NC (8)

Acuron Residual weed control. Adrian Moses*[1], Gordon Vail[2], Scott Cully[3], Tom Beckett[2]; [1]Syngenta, Ames, IA, [2]Syngenta, Greensboro, NC, [3]Syngenta, Marion, IL (9)

†Carryover of Common Corn and Soybean Herbicides to Various Cover Crop Species in Missouri. Cody D. Cornelius, Jaime Farmer, Mandy Bish, Alex Long, Meghan Biggs, and Kevin Bradley. Cody D. Cornelius*[1], Jaime Farmer[2], Mandy D. Bish[3], Alex R. Long[4], Meghan E. Biggs[4], Kevin W. Bradley[4]; [1]University of Missouri, Columbia MO, MO, [2]University of Missouri-Columbia, Columbia, MO, [3]University of Missouri, 65211, MO, [4]University of Missouri, Columbia, MO (10)

†The impact of fall-planted cover crop monocultures and simple mixtures on weed presence in corn. Victoria J. Ackroyd*[1], Christy L. Sprague[2]; [1]Michigan State University, 48824, MI, [2]Michigan State University, East Lansing, MI (11)

†Dose Response of Selected Glyphosate-Resistant Weeds to Prepackaged Mixture of Fluthiacet-methyl and Mesotrione Applied at Two Growth Stages. Zahoor A. Ganie*[1], Gail Stratman[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]FMC Corporation, Stromsburg, NE (12)

†Sweet corn and popcorn tolerance to postemergence applications of nicosulfuron + mesotrione + isoxadifen-ethyl. Danielle R. Cooney*[1], Larry H. Hageman[2], Helen L. Flanigan[3], Scott E. Swanson[4]; [1]University of Illinois, Urbana, IL, [2]DuPont, ROCHELLE, IL, [3]DuPont, Johnston, IA, [4]DuPont, Rochelle, IL (13)

†ALS-Inhibiting Herbicide Dose and Plant Size Influence the Control of ALS-Resistant Shattercane Populations. Rodrigo Werle*[1], Roberto L. Martins[2], Lowell D. Sandell[3], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]São Paulo State University, Botucatu, Brazil, [3]Valent USA Corporation, Lincoln, NE (14)

Volunteer Glyphosate and Glufosinate Resistant Corn Competitiveness and Control in Glyphosate and Glufosinate Resistant Corn. Nader Soltani*, Christy Shropshire, Peter H. Sikkema; University of Guelph, Ridgetown, ON (15)

†Confirmation of HPPD Resistant Common Waterhemp in Nebraska. Maxwel C. Oliveira*[1], Jon E. Scott[2], Aaron S. Franssen[3], Vinod K. Shivrain[4], Stevan Z. Knezevic[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]Syngenta Crop Protection, Seward, NE, [4]Syngenta, Greensboro, NC (110)

Herbicides to Manage Putative HPPD-Resistant Waterhemp in Corn. Damian D. Franzenburg*, Micheal D. Owen, James M. Lee, Jacob S. Eeling; Iowa State University, Ames, IA (111)

†Revisiting Traillate for Wild Oat Control in Wheat. Morgan D. Hanson*, Kirk A. Howatt; NDSU, Fargo, ND (112)

Stewardship of BASF corn herbicides. Walter E. Thomas*, Steven Bowe, Luke Bozeman; BASF Corporation, Research Triangle Park, NC (198)

Introduction of SYN-A205 for Atrazine-free Weed Control in Corn. Ryan D. Lins*[1], Scott Cully[2], Thomas H. Beckett[3], Gordon Vail[4], John Foresman[4]; [1]Syngenta, Byron, MN, [2]Syngenta, Marion, IL, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta, Greensboro, NC (199)

Acuron: Preemergence Weed Control and Corn Safety. Thomas H. Beckett*[1], Scott E. Cully[2], Ryan D. Lins[3], Gordon Vail[1]; [1]Syngenta, Greensboro, NC, [2]Syngenta, Marion, IL, [3]Syngenta, Byron, MN (200)

Acuron tolerance in sweet corn. Nicholas E. Hausman*[1], Martin M. Williams II[2]; [1]University of Illinois, Urbana, IL, [2]USDA-ARS, Urbana, IL (201)

Revulin™ Q: A New Postemergence Herbicide for Seed Corn. Paul Marquardt*[1], Jessica Bugg[2], Kelly Barnett[3], Michael Meyer[4], Jeffery Carpenter[5], Helen A. Flanigan[6]; [1]DuPont Crop Protection, Des Moines, IA, [2]DuPont Crop Protection, Deleware, OH, [3]DuPont Crop Protection, Whiteland, IN, [4]DuPont Crop Protection, Norwalk, IA, [5]DuPont Crop Protection, Johnston, IA, [6]DuPont, Greenwood, IN (202)

DuPont Revulin Q Herbicide, A New Postemergence Herbicide for Sweetcorn and Popcorn. Jeff Krumm*[1], Greg Hannig[2], Keith Diedrick[3], Jessica Bugg[4], Helen Flannigan[5]; [1]DuPont Crop Protection, Hastings, NE, [2]DuPont Crop Protection, Palmyra, NY, [3]DuPont Crop Protection, Rio, WI, [4]DuPont Crop Protection, Richwood, OH, [5]DuPont Crop Protection, Greenwood, IN (203)

Using Inzen Z sorghum to manage annual grasses postemergence. Curtis R. Thompson*[1], Randall S. Currie[2], Phillip W. Stahlman[3], Alan J. Schlegel[4], Gary Cramer[5], Dallas E. Peterson[1], Jennifer L. Jester[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS, [3]Kansas State University, Hays, KS, [4]Kansas State University, Tribune, KS, [5]Kansas State University, Hutchinson, KS (204)

Effect of Previous Atrazine use on Enhanced Atrazine Degradation in Northern United States Soils. Thomas C. Mueller*[1], Randall S. Currie[2], Anita Dille[3], William Curran[4], Christy L. Sprague[5], James Martin[6], Kevin W. Bradley[7], Mark L. Bernards[8], Micheal D. Owen[9], Sharon Clay[10], Stevan Z. Knezevic[11], Vince M. Davis[12]; [1]University of Tennessee, Knoxville, TN, [2]Kansas State University, Garden City, KS, [3]Kansas State University, Manhattan, KS, [4]Penn State, University Park, PA, [5]Michigan State University, East Lansing, MI, [6]University of Kentucky, Princeton, KY, [7]University of Missouri, Columbia, MO, [8]Western Illinois University, Macomb, IL, [9]Iowa State University, Ames, IA, [10]South Dakota State University, Brookings, SD, [11]University of Nebraska-Lincoln, Concord, NE, [12]University of Wisconsin-Madison, Madison, WI (205)

Weed control in drought tolerant and conventional corn with increasing levels of irrigation with and with out a wheat cover crop. Randall S. Currie*, Isaya Kisekka, Sarah Zukoff, Pat Geier, Anthony Zukoff; Kansas State Univ., Garden City, KS (206)

Improving the establishment and subsequent yield of alfalfa interseeded into silage corn with prohexadione. Mark J. Renz*[1], John Grabber[2]; [1]University of Wisconsin Madison, Madison, WI, [2]USDA-ARS, Madison, WI (207)

Varro - A New Herbicide for Grass Control in Northern Plains Cereals. Kevin B. Thorsness*[1], Steven R. King[2], Dean W. Maruska[3], Michael C. Smith[4], Charlie P. Hicks[5], George S. Simkins[6], Mark A. Wrucke[7]; [1]Bayer CropScience, Fargo, ND, [2]Bayer CropScience, Research Triangle Park, NC, [3]Bayer CropScience, Warren, MN, [4]Bayer CropScience, Sabin, MN, [5]Bayer CropScience, Fort Collins, CO, [6]Bayer CropScience, St. Paul, MN, [7]Bayer CropScience, Farmington, MN (208)

Droplet size effects on wild oat (*Avena ludoviciana*) control in Australian wheat and canola production. J Connor Ferguson*[1], Chris C. O'Donnell[1], Greg R. Kruger[2], Andrew J. Hewitt[1]; [1]The University of Queensland, Gatton, Australia, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (209)

Agronomic Crops II (Soybeans, Dry Beans, Sugar Beets)

Weed management with tankmixes of S-metolachlor, imazethapyr and linuron in dry bean. Nader Soltani*[1], Rob E. Nurse[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Agriculture Canada, Harrow, ON (16)

Dupont Trivence: A Second Year Review of a New Preemergence Herbicide in Soybean. Kelly Barnett*[1], Helen A. Flanigan[2], Kevin L. Hahn[3], J. Dan Smith[4]; [1]DuPont Crop Protection, Whiteland, IN, [2]DuPont, Greenwood, IN, [3]DuPont Crop Protection, Bloomington, IL, [4]DuPont Crop Protection, Madison, MS (17)

†Comparison of Herbicide and Cover Crop Utilization for Horseweed Suppression Before and During a Soybean Crop. Andi M. Christenson*[1], J. Anita Dille[2], Kraig L. Roozeboom[1], Dallas E. Peterson[1]; [1]Kansas State University, Manhattan, KS, [2]Agronomy Department, Kansas State University, Manhattan, KS (18)

DuPont Afforia Herbicide: New Burndown Option for Variable pH Soils. Keith A. Diedrick*[1], Helen A. Flanigan[2], Keith D. Johnson[3], Bruce W. Carlson[4]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont, Greenwood, IN, [3]DuPont Crop Protection, Grand Forks, ND, [4]DuPont Crop Protection, Lindstrom, MN, MN (19)

Enlist™ and Enlist E3™ Soybean Crop Tolerance. Joe Armstrong*[1], Patricia L. Prasifka[2], David C. Ruen[3], Mike M. Moechnig[4], David M. Simpson[5]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, West Fargo, ND, [3]Dow AgroSciences, Lanesboro, MN, [4]Dow AgroSciences, Toronto, SD, [5]Dow AgroSciences, Indianapolis, IN (20)

Enlist E3™ Soybean Weed Control Systems in Midwest. Jeff M. Ellis*[1], David C. Ruen[2], Mike M. Moechnig[3], Eric F. Scherder[4], Kristin Rosenbaum[5], Laura A. Campbell[6], Fikru Haile[7], Leah L. Granke[8]; [1]Dow AgroSciences, Smithville, MO, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Toronto, SD, [4]Dow AgroSciences, Huxley, IA, [5]Field Scientist, Crete, NE, [6]Dow AgroSciences, Carbondale, IL, [7]Dow AgroSciences, Carmel, IN, [8]Dow AgroSciences, Columbus, OH (21)

Tolerance of banana pepper (*Capsicum annuum*) to *s*-metolachlor and clomazone. Mohsen Mohseni Moghadam, Douglas Doohan, Andrea S. Leiva Soto*; The Ohio State University - Ohio Agricultural Research and Development Center, Wooster, OH (22)

†Relating dicamba injury and residue to yield reduction in dry bean. Theresa A. Reinhardt*, Rich Zollinger; North Dakota State University, Fargo, ND (23)

†Cover crop species response to simulated half-life doses of soybean and corn herbicides. Brittany Parker*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (24)

†Summer annual weed control as affected by fall, preplant and PRE timing of soybean residual herbicides. Kyle R. Russell*[1], Mark L. Bernards[1], Bryan Young[2], Aaron G. Hager[3]; [1]Western Illinois University, Macomb, IL, [2]Purdue University, W. Lafayette, IN, [3]University of Illinois, Urbana, IL (25)

†Soybean yield response to cover crop and winter annual weed removal time and soybean planting date. Aaron P. Prins*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (26)

†Full Rates, Multiple Herbicides, or Both? Considerations for Best Management Practices for Residual Control of Waterhemp in Soybean. Nick T. Harre*[1], Joseph L. Matthews[2], Julie M. Young[2], Mark Bernards[3], Aaron G. Hager[4], Bryan Young[5]; [1]Purdue University, West Lafayette, IL, [2]Southern Illinois University, Carbondale, IL, [3]Western Illinois University, Macomb, IL, [4]University of Illinois, Urbana, IL, [5]Purdue University, W. Lafayette, IN (27)

Options for controlling glyphosate-resistant kochia preplant. Brian M. Jenks*; North Dakota State University, Minot, ND (28)

†Volunteer Corn Competes with Sugarbeet for Nitrogen. Amanda C. Harden*, Christy L. Sprague; Michigan State University, East Lansing, MI (29)

†Cover Crops and Herbicide Programs for Management of Palmer Amaranth (*Amaranthus palmeri*) in Soybean Systems Resistant to Glyphosate and Glufosinate. Douglas J. Spaunhorst*, William G. Johnson; Purdue, West Lafayette, IN (30)

†Influence of Herbicide Programs on Glyphosate-Resistant Common Waterhemp Control in Glyphosate Tolerant Soybean. Debalin Sarangi*[1], Lowell D. Sandell[1], Amit J. Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (31)

†Influence of late season herbicide application on seed production and fecundity of glyphosate-resistant giant ragweed (*Ambrosia trifida*). Simranpreet Kaur*[1], Roger Elmore[2], Zac J. Reicher[3], Amit J. Jhala[4]; [1]University of Nebraska Lincoln, Lincoln, NE, [2]University of Nebraska lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska-Lincoln, USA, Lincoln, NE (32)

†Influence of preharvest herbicide applications on color retention of canned black beans. Amanda M. Goffnett*[1], Christy L. Sprague[1], Karen A. Cichy[2]; [1]Michigan State University, East Lansing, MI, [2]USDA-ARS, East Lansing, MI (33)

Edamame tolerance to bentazon, fomesafen, imazamox, linuron, and sulfentrazone. James L. Moody*[1], Martin M. Williams II[2], Randall L. Nelson[2]; [1]University of Illinois, Urbana, IL, [2]USDA-ARS, Urbana, IL (34)

Technical attributes of Fierce XLT. Eric J. Ott*[1], John A. Pawlak[2], Dawn E. Refsell[3], Lowell Sandell[4], Trevor Dale[5]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA Corporation, Lansing, MI, [3]Valent USA Corporation, Lathrop, MO, [4]Valent USA Corporation, Lincoln, NE, [5]Valent USA Corporation, Plymouth, MN (35)

†Investigation of fluridone as a preemergent herbicide in soybean. Austin H. Straatmann*[1], Mandy D. Bish[2], Alex R. Long[2], Meghan E. Biggs[2], Kevin W. Bradley[2]; [1]University of Missouri, Villa Ridge, MO, [2]University of Missouri, Columbia, MO (36)

Performance of a New Clethodim Formulation. Laura Hennemann*, Gregory Dahl, Joe Gednalske, Eric Spandl, Lillian Magidow; Winfield, River Falls, WI (37)

†Monitoring the Changes in Glyphosate-resistant Weed Populations in Continuous Dicamba-resistant Soybean for Four Years. Isaiah L. Akers*, Meghan E. Biggs, Alex R. Long, Mandy D. Bish, Kevin W. Bradley; University of Missouri, Columbia, MO (38)

†Winter annual weeds and cereal rye suppression of waterhemp in soybean. Kristina Simmons*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (39)

†Comparison of Single Mode of Action Herbicides Applied Preemergence to Glyphosate-Resistant Palmer Amaranth in Indiana. Joseph T. Ikley*[1], Travis R. Legleiter[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (103)

Comparison of Herbicide Mode of Action Combinations Applied Preemergence to Glyphosate-Resistant Palmer Amaranth in Indiana. Joseph T. Ikley*[1], Travis R. Legleiter[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (104)

†Current Status of Herbicide Resistance in Shattercane and Johnsongrass Populations from Northern Kansas, Eastern Missouri and Southern Nebraska. Rodrigo Werle*[1], Amit J. Jhala[1], Melinda K. Yerka[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]USDA-ARS, Lincoln, NE (105)

†Control and Distribution of Glyphosate Resistant Common Ragweed (*Ambrosia artemisiifolia* L.) in Ontario. Annemarie C. Van Wely*[1], Peter H. Sikkema[1], Darren Robinson[1], David C. Hooker[1], Mark B. Lawton[2]; [1]University of Guelph, Ridgetown, ON, [2]Monsanto Canada, Guelph, ON (106)

†Glyphosate-Resistant Common Waterhemp in Nebraska: Confirmation and Control in Soybean. Debalin Sarangi*[1], Lowell D. Sandell[1], Stevan Z. Knezevic[2], Jatinder S. Aulakh[3], John L. Lindquist[1], Suat Irmak[3], Amit J. Jhala[4]; [1]University of Nebraska -Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]University of Nebraska- Lincoln, Lincoln, NE, [4] University of Nebraska-Lincoln, USA, Lincoln, NE (107)

†Integrated Management of Glyphosate-Resistant Giant Ragweed with Tillage and Herbicides in Soybean. Zahoor A. Ganie*[1], Lowell D. Sandell[1], John L. Lindquist[1], Greg R. Kruger[2], Mithila Jugulam[3], Amit J. Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE, [3]Kansas State University, Manhattan, KS (108)

†Dose Response of Glyphosate-Resistant Weeds to Enlist Duo™ Applied at Two Growth Stages. Parminder S. Chahal*[1], Jatinder S. Aulakh[2], Amit J. Jhala[1], Kristin Rosenbaum[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Field Scientist, Crete, NE (109)

†Influence of Various Cover Crop Species on Winter and Summer Annual Weed Emergence. Cody D. Cornelius*; University of Missouri, Columbia MO, MO (113)

†Light interception in soybean determined through digital imagery analysis affects soybean yield and weed suppression. Thomas R. Butts*[1], Jason K. Norsworthy[2], Greg R. Kruger[3], Lowell Sandell[4], Bryan Young[5], Lawrence E. Steckel[6], Mark M. Loux[7], Kevin W. Bradley[8], William G. Johnson[9], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Arkansas, Fayetteville, AR, [3]University of Nebraska-Lincoln, USA, Lincoln, NE, [4]Valent USA Corporation, Lincoln, NE, [5]Purdue University, W. Lafayette, IN, [6]University of Tennessee, Jackson, TN, [7]Ohio State University, Columbus, OH, [8]University of Missouri, Columbia, MO, [9]Purdue, West Lafayette, IN (114)

†Competitive Interactions of Four Amaranthaceae Species with Soybeans. Lauren M. Schwartz*[1], Bryan Young[2], David J. Gibson[3]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN, [3]Southern Illinois University, Carbondale, Carbondale, IL (115)

Comparison of Herbicide Programs with and without Residual Herbicides for Weed Control in Glufosinate-Resistant soybean. Jatinder S. Aulakh*[1], John L. Lindquist[2], Amit J. Jhala[3]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (153)

Influence of tillage methods on management of *Amarnathus* species in soybean. Jaime Farmer*[1], Vince M. Davis[2], William G. Johnson[3], Mark M. Loux[4], Jason K. Norsworthy[5], Lawrence E. Steckel[6], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Wisconsin-Madison, Madison, WI, [3]Purdue, West Lafayette, IN, [4]Ohio State University, Columbus, OH, [5]University of Arkansas, Fayetteville, AR, [6]University of Tennessee, Jackson, TN (154)

Palmer Amaranth Weed Control with Enlist Weed Control Systems. David M. Simpson*[1], Kristin Rosenbaum[2], Jeff M. Ellis[3], John S. Richburg[4], Fikru Haile[5], Leah L. Granke[6], Gary D. Thompson[7], Bobby H. Haygood[8], Larry W. Walton[9]; [1]Dow AgroSciences, Indianapolis, IN, [2]Field Scientist, Crete, NE, [3]Dow AgroSciences, Smithville, MO, [4]Dow AgroSciences, Headland, AL, [5]Dow AgroSciences, Carmel, IN, [6]Dow AgroSciences, Columbus, OH, [7]Dow AgroSciences, Omaha, AR, [8]Dow AgroSciences, Collierville, TN, [9]Dow AgroSciences, Tupelo, TN (155)

Weed Management Stewardship of Engenia™ Herbicide in Dicamba Tolerant Soybean. Shane Hennigh*[1], John Frihauf[2], Chad Brommer[2]; [1]BASF Corporation, Story City, IA, [2]BASF Corporation, Research Triangle Park, NC (156)

Application Stewardship of Engenia™ Herbicide in Dicamba Tolerant Crops. Dustin Lewis*[1], Chad Brommer[2], Ching Feng[2], Walter E. Thomas[2]; [1]BASF Corporation, Urbana, IL, [2]BASF Corporation, Research Triangle Park, NC (157)

Control of volunteer Enlist corn in soybean. Peter H. Sikkema*, Nader Soltani; University of Guelph, Ridgetown, ON (158)

The effect of auxinic herbicides on growth and yield of non-auxin resistant soybeans. Kevin R. McGregor*[1], Micheal D. Owen[2]; [1]Iowa State University, Ankeny, IA, [2]Iowa State University, Ames, IA (159)

Evaluation of Weed Control Programs Utilizing HPPD-Tolerant Soybeans. Aaron S. Franssen*[1], Dain E. Bruns[2], Thomas H. Beckett[3], Brett R. Miller[4], Donald J. Porter[3]; [1]Syngenta Crop Protection, Seward, NE, [2]Syngenta Crop Protection, Marysville, OH, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta Crop Protection, Minnetonka, MN (160)

Broadspectrum weed control in soybeans with Fierce XLT. Trevor M. Dale*[1], Eric J. Ott[2], Dawn E. Refsell[3], Lowell Sandell[4], John A. Pawlak[5]; [1]Valent USA Corporation, Sioux Falls, SD, [2]Valent USA Corporation, Greenfield, IN, [3]Valent USA Corporation, Lathrop, MO, [4]Valent USA Corporation, Lincoln, NE, [5]Valent USA Corporation, Lansing, MI (161)

Fierce XLT: A new herbicide for control of *Amaranth* species in soybeans. John A. Pawlak[1], Dawn E. Refsell[2], Trevor M. Dale[3], Eric J. Ott[4], Lowell D. Sandell*[5]; [1]Valent USA Corporation, Lansing, MI, [2]Valent USA Corporation, Lathrop, MO, [3]Valent USA Corporation, Sioux Falls, SD, [4]Valent USA Corporation, Greenfield, IN, [5]Valent USA Corporation, Lincoln, NE (162)

Old Dogs New Tricks: Value of Metribuzin in Modern Weed Control for Soybeans. Neha Rana*[1], Keith Kretzmer[1], John B. Willis[1], Alejandro Perez-Jones[1], Paul Feng[1], Jesse Gilsinger[2]; [1]Monsanto Company, Chesterfield, MO, [2]Monsanto Company, Mount Olive, NC (163)

Waterhemp Control in Sugarbeet. Aaron L. Carlson*, Thomas J. Peters; North Dakota State University, Fargo, ND (164)

Glyphosate-resistant *Conyza canadensis* [L.] Cronq. and *Ambrosia trifida* L. in Ontario: Control for Balance GT soybean. Scott Ditschun*; University of Guelph, Guelph, ON (190)

Herbicide Physiology

†2,4-D Uptake and Translocation in Enlist™ Crops. Joshua J. Skelton*[1], David M. Simpson[2], Mark A. Peterson[3], Dean E. Riechers[4]; [1]University of Illinois, Champaign, IL, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Indianapolis, IL, [4]University of Illinois, Urbana, IL (40)

†Effect of Foliar Fertilizers, Water pH, and Plant Height on Horseweed Control with Mesotrione. Pratap Devkota*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (41)

†The EPSPS Pro106Ser substitution solely accounts for glyphosate resistance in a goosegrass population from Tennessee. Janel L. Huffman*[1], Chance W. Riggins[2], Lawrence E. Steckel[3], Patrick J. Tranel[2]; [1]University of Illinois, Champaign/Urbana, IL, [2]University of Illinois, Urbana, IL, [3]University of Tennessee, Jackson, TN (42)

Role of Absorption, Translocation, and EPSPS Sensitivity in the Mechanism of Glyphosate Resistance in Wisconsin Giant Ragweed. Courtney E. Glettner[1], Christopher R. Van Horn[2], Melinda K. Yerka[3], Philip Westra[2], David E. Stoltenberg*[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Colorado State University, Fort Collins, CO, [3]USDA-ARS, Lincoln, NE (43)

†Characterization of Wisconsin Giant Ragweed Resistance to Cloransulam-Methyl. Stacey M. Marion*, Vince M. Davis, David E. Stoltenberg; University of Wisconsin-Madison, Madison, WI (44)

†HPPD Resistance in Nebraska's Waterhemp: Enhanced Metabolism or Target Site Mutation. Maxwel C. Oliveira*[1], Todd Gaines[2], Stevan Z. Knezevic[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Colorado State University, Fort Collins, CO, [3]University of Nebraska-Lincoln, Concord, NE (45)

Glyphosate resistance in Palmer amaranth in Kansas: what do we know now? Amar S. Godar*[1], Dallas E. Peterson[1], Phillip W. Stahlman[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (131)

†Genetics and inheritance of non-target-site resistances to atrazine and mesotrione in an Illinois waterhemp population. Janel L. Huffman*[1], Nicholas E. Hausman[2], Aaron G. Hager[2], Dean E. Riechers[2], Patrick J. Tranel[2]; [1]University of Illinois, Champaign/Urbana, IL, [2]University of Illinois, Urbana, IL (132)

†Evaluation of Cytochrome P450 Expression in Mesotrione-Resistant and -Sensitive Waterhemp (*Amaranthus tuberculatus*) Populations. Rong Ma*[1], Kris N. Lambert[2], Dean E. Riechers[3]; [1]UIUC, Urbana, IL, [2]University of Illinois Champaign-Urbana, Urbana, IL, [3]University of Illinois, Urbana, IL (133)

†Physiological and Molecular Characterization of Mesotrione Resistance in Palmer amaranth (*Amaranthus palmeri*) from Kansas. Sridevi Betha*, Amar S. Godar, Curtis R. Thompson, Dallas E. Peterson, Mithila Jugulam; Kansas State University, Manhattan, KS (134)

†Relationship between *EPSPS* Copies, Expression, and Level of Resistance to Glyphosate in Common Waterhemp (*Amaranthus rudis*) from Kansas. Andrew J. Dillon*, Vijay K. Varanasi, Dallas E. Peterson, Mithila Jugulam; Kansas State University, Manhattan, KS (135)

†Synergistic Antagonism: Characterizing the Interaction of Paraquat and Metribuzin on Horseweed. Garth W. Duncan*[1], Julie M. Young[1], Bryan Young[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, W. Lafayette, IN (136)

†2,4-D Metabolism in Enlist™ Crops. Joshua J. Skelton*[1], David M. Simpson[2], Mark A. Peterson[3], Dean E. Riechers[4]; [1]University of Illinois, Champaign, IL, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Indianapolis, IL, [4]University of Illinois, Urbana, IL (137)

†2,4-D Translocation and Metabolism in Sensitive and Tolerant Red Clover (*Trifolium pratense*) Lines. Tara L. Burke*, Michael Barrett; University of Kentucky, Lexington, KY (138)

Extension

2014 NCWSS Weed Contest. Dave Johnson*; DuPont Pioneer, Johnston, IA (46)

Weed Control and Crop Tolerance with HPPD-Tolerant Soybeans in Northeast Nebraska. 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 (47)

†Herbicide Options to Control HPPD Resistant Waterhemp in Nebraska. Maxwel C. Oliveira*[1], Jon E. Scott[2], Aaron S. Franssen[3], Stevan Z. Knezevic[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]Syngenta Crop Protection, Seward, NE (48)

Weed Control and Crop Tolerance with New Soybean Traits in Northeast Nebraska. Jon E. Scott*[1], Leo D. Charvat[2], John Frihauf[3], Kevin Watteyne[4], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE, [3]BASF Corporation, Research Triangle Park, NC, [4]Bayer CropScience, Lincoln, NE (49)

Volunteer Glyphosate Resistant Soybean Control in Glyphosate Resistant Corn. Stevan Z. Knezevic*[1], Amit J. Jhala[2], Greg R. Kruger[2], Lowell D. Sandell[3], Maxwel C. Oliveira[4], Jeffrey A. Golus[5], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE, [3]Valent USA Corporation, Lincoln, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]University of Nebraska-Lincoln, North Platte, NE (50)

How do growers' current practices relate to proposed label requirements for upcoming herbicide-resistant crop technologies? Lizabeth Stahl*[1], Lisa M. Behnken[2], Fritz Breitenbach[3], Ryan P. Miller[4], David Nicolai[5]; [1]University of MN Extension, Worthington, MI, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota, St. Paul, MN, [4]University of MN Extension, Rochester, MN, [5]University of MN Extension, Farmington, MN (51)

Take Control - Herbicide systems to control SOA 2 and 9 resistant giant ragweed in soybean. Lisa Behnken*, Fritz Breitenbach, Jeffrey L. Gunsolus; University of Minnesota, St. Paul, MN (52)

†Late season weed escape survey identifies increasing numbers of herbicide-resistant *Amaranthus spp.* in Wisconsin. Thomas R. Butts*[1], Ross A. Recker[2], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Monsanto Company, Monmouth, IL (53)

Manual for Propane-Fueled Flame Weeding in Corn, Soybean, and Sunflower. Stevan Z. Knezevic*[1], Avishek Datta[2], Chris Bruening[3], George Gogos[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Lincoln, NE (54)

Using grower survey responses to assess herbicide resistance issues and educational needs. Lizabeth Stahl*[1], Lisa M. Behnken[2], Fritz Breitenbach[3], David A. Nicolai[4], Ryan P. Miller[5]; [1]University of MN Extension, Worthington, MI, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota, St. Paul, MN, [4]University of MN Extension, Farmington, MN, [5]University of MN Extension, Rochester, MN (55)

Control of glyphosate-resistant common waterhemp in glufosinate-resistant soybean. Amit J. Jhala*[1], Lowell D. Sandell[2], Debalin Sarangi[3]; [1]University of Nebraska-Lincoln, USA, Lincoln, NE, [2]Valent USA Corporation, Lincoln, NE, [3]University of Nebraska-Lincoln, Lincoln, NE (183)

Enlist Ahead App: management resources for the Enlist Weed Control System. David E. Hillger*[1], Andy Asbury[2], Ryan Keller[3], John Laffey[4], Ralph Lassiter[5], Jonathan Siebert[6], Jake Wiltrout[7]; [1]Dow AgroSciences, Noblesville, IN, [2]Dow AgroSciences, Dahinda, IL, [3]Dow AgroSciences, Rochester, MN, [4]Dow AgroSciences, Maryville, MO, [5]Dow AgroSciences, Raleigh, NC, [6]Dow AgroSciences, Greenville, MS, [7]Dow AgroSciences, Indianapolis, IN (184)

Enlist 360 Education Series: education, training and outreach on the Enlist Weed Control System. Ryan Keller*[1], Andy Asbury[2], David E. Hillger[3], John Laffey[4], Ralph Lassiter[5], Jonathan Siebert[6], Jake Wiltrout[7]; [1]Dow AgroSciences, Rochester, MN, [2]Dow AgroSciences, Dahinda, IL, [3]Dow AgroSciences, Noblesville, IN, [4]Dow AgroSciences, Maryville, MO, [5]Dow AgroSciences, Raleigh, NC, [6]Dow AgroSciences, Greenville, MS, [7]Dow AgroSciences, Indianapolis, IN (185)

Horticulture, Ornamentals, and Turf

Stevia Tolerance to Herbicides. Donald Penner*, Jan Michael; Michigan State University, East Lansing, MI (56)

†Screening of Herbicides for Selective Weed Control in African marigolds (*Tagetes erecta*). Katie J. Demers*[1], Robert Hartzler[1], John A. Greaves[2], Norman P. Cloud[2]; [1]Iowa State University, Ames, IA, [2]Kemin Industries Inc, Des Moines, IA (57)

Effect of Simulated Glyphosate Drift on Seed Pieces From Four Potato Processing Cultivars. Collin P. Auwarter*[1], Harlene M. Hatterman-Valenti[2]; [1]ndsu, fargo, ND, [2]North Dakota State University, Fargo, ND (58)

Which bromoxynil should I use for broadleaf weed control in onion? Harlene M. Hatterman-Valenti*[1], Collin P. Auwarter[2]; [1]North Dakota State University, Fargo, ND, [2]NDSU, Fargo, ND (186)

Response of tomato (*Solanum lycopersicum*) to sub-lethal doses of 2,4-D and glyphosate. Mohsen Mohseni Moghadam*, Andrea S. Leiva Soto, Louceline Fleuridor, Roger Downer, Douglas Doohan; The Ohio State University - Ohio Agricultural Research and Development Center, Wooster, OH (187)

Herbicide Safety on Beardless Iris Seedlings. John Kaufmann*; Kaufmann Agknowledge, Okemos, MI (188)

Invasive Weeds

Biological Control of Garlic Mustard in North America. Jeanie Katovich*, Roger L. Becker; University of Minnesota, St. Paul, MN (59)

Impact of Native Prairie Functional Groups On Persistence of Canada Thistle. Roger L. Becker*[1], Milt Haar[2], Lee Klossner[3]; [1]University of Minnesota, St. Paul, MN, [2]US Department of Interior, Interior, SD, [3]University of Minnesota, Lamberton, MN (60)

Japanese Stiltgrass Control in Managed Woodlands. Joe Omielan*, Michael Barrett; University of Kentucky, Lexington, KY (61)

Invasive Species Weed Seed Viability after Composting. Mark J. Renz*[1], Joe Van Rossum[2]; [1]University of Wisconsin Madison, Madison, WI, [2]University of Wisconsin Extension, Madison, WI (189)

Rangeland, Pasture, and Industrial Vegetation Management

Management of Callery pear (*Pyrus Calleryana*) on urban roadsides. Carey Page*[1], E. Scott Flynn[2], Reid Smeda[1]; [1]University of Missouri, Columbia, MO, [2]Dow Agrosciences, Lee's Summit, MO (62)

Foliar-applied herbicides for indigobush control. Walter H. Fick*; Kansas State University, Manhattan, KS (191)

Vegetation Management Options Under Cable Barriers. Joe Omielan*; University of Kentucky, Lexington, KY (192)

Weed Biology, Ecology, Management

Confirmation of glyphosate-resistant common ragweed in Nebraska. Lucas Baldridge*[1], Andre Silva[1], Rodrigo Werle[1], Lowell D. Sandell[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (63)

†Critical duration of grass weed interference in grain sorghum. Gared E. Shaffer*[1], J. Anita Dille[2]; [1]Kansas State University, Manhattan, KS, [2]Agronomy Department, Kansas State University, Manhattan, KS (64)

†Influence of tillage systems on glyphosate-resistant waterhemp in Indiana. Joseph M. Heneghan*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (65)

†Weed suppression with narrow rows and high seeding rates in grain sorghum. Cade A. Hewitt*[1], J. Anita Dille[2], Phillip W. Stahlman[3], Curtis R. Thompson[1]; [1]Kansas State University, Manhattan, KS, [2]Agronomy Department, Kansas State University, Manhattan, KS, [3]Kansas State University, Hays, KS (66)

Population-Dependent Dominance of the R-Allele in *Amaranthus tuberculatus* Resistant to PPO Inhibitors. R. Joseph Wuerffel*[1], Bryan Young[2]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN (67)

†Can Foliar-Applied Gibberellic Acid Influence Sex Determination or Pistillate Flower Morphology in *Amaranthus tuberculatus*? Brent Sunderlage*[1], R. Joseph Wuerffel[1], Bryan Young[2]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN (68)

†Control of Several Southern Illinois Palmer Amaranth Populations with Fomesafen and Lactofen. Kayla N. Wiedau*, R. Joseph Wuerffel, Joseph L. Matthews, Ronald F. Krausz; Southern Illinois University, Carbondale, IL (69)

†Influence of Plant Height and Growth Temperature on Glyphosate Efficacy in Common Lambsquarters. Randy D. Degreeff*[1], Mithila Jugulam[2], Amar S. Godar[2], J. Anita Dille[3]; [1]Kansas State University, SALINA, KS, [2]Kansas State University, Manhattan, KS, [3]Agronomy Department, Kansas State University, Manhattan, KS (70)

†Importance of emergence date on the development of Palmer amaranth (*Amaranthus palmeri*). Heidi R. Davis*, Reid Smeda; University of Missouri, Columbia, MO (71)

†Association between seed dormancy and resistances to ALS and PPO inhibitors in waterhemp. Patrick J. Tranel[1], Chenxi Wu*[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois at Champaign-Urbana, Urbana, IL (72)

†Ecological Fitness of Glyphosate Resistant Kochia (*Kochia scoparia*). O. Adewale Osipitan*[1], J. Anita Dille[1], Phillip W. Stahlman[2], David C. Hartnett[3], Allan K. Fritz[1]; [1]Agronomy Department, Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS, [3]Biological Sciences, Kansas State University, Manhattan, KS (73)

†Effect of Herbicides on Recovery and Pathogenicity of *Clavibacter michiganensis* subsp. *nebraskensis*, Causal Agent of Goss's Wilt of Corn. Joseph T. Ikley*[1], Kiersten A. Wise[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (74)

N_2O Emissions from Soybean as Influenced by Herbicide Management Strategy and Row Width. Rebecca R. Bailey*, Thomas R. Butts, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (75)

†Rate and duration of emergence in response to tillage and competition effects in 2,4-D resistant common waterhemp (*Amaranthus tuberculatus*). Lacy J. Leibhart*[1], Lowell D. Sandell[1], Zac J. Reicher[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (76)

†Response of velvetleaf populations from south-western Nebraska to glyphosate. Bruno Canella Vieira*[1], Spencer L. Sameulson[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (77)

†Frequency of atrazine resistance in kochia populations from south-western Nebraska. Spencer L. Sameulson*[1], Bruno Canella Vieira[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (78)

†Factors Affecting the Germination and Emergence of Glyphosate-Resistant Hybrid and Volunteer Corn (*Zea mays* L.). Parminder S. Chahal*[1], Greg R. Kruger[2], Humberto Blanco-Canqui[3], Amit J. Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE, [3]Assistant Professor, Lincoln, NE (79)

Screening for resistance to 20X rates of glyphosate in biotypes of *Conyza canadensis* from soybean fields and non-agricultural habitats in Ohio and Iowa. Zachery T. Beres*[1], Emily E. Ernst[1], Allison A. Snow[1], Jason T. Parrish[1], Micheal D. Owen[2], Bruce A. Ackley[1], Mark M. Loux[1]; [1]Ohio State University, Columbus, OH, [2]Iowa State University, Ames, IA (80)

†Influence of spring tillage on common ragweed emergence in Nebraska. Ethann R. Barnes*[1], Rodrigo Werle[1], Lowell D. Sandell[2], Amit J. Jhala[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Valent USA Corporation, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (81)

†Giant Ragweed Seed Production and Retention in Soybean and Field Margins. Jared J. Goplen*[1], Jeffrey L. Gunsolus[2], Craig C. Sheaffer[2], Roger L. Becker[2], Jeffrey A. Coulter[2], Fritz Breitenbach[2], Lisa Behnken[2], Gregg A. Johnson[2]; [1]University of Minnesota, Saint Paul, MN, [2]University of Minnesota, St. Paul, MN (82)

†Identification and Determination of Glyphosate-Resistant *Amaranthus* spp. using Molecular Markers. Brittany Janney*, Rong Ma, Kris N. Lambert, Dean E. Riechers; University of Illinois, Urbana, IL (83)

†Termination strategies for winter rye and overwintering annual ryegrass with glyphosate. Daniel H. Smith*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (84)

Common and Tartary Buckwheat as Summer Cover Crops for Weed Suppression in Vegetable Cropping Systems. Mary T. Saunders Bulan, David E. Stoltenberg*, Joshua L. Posner; University of Wisconsin-Madison, Madison, WI (85)

†Differences in final biomass among glyphosate-resistant and glyphosate-susceptible maternal families of *Conyza canadensis* in Ohio: a pilot field experiment. Beres T. Zachery*, Allison A. Snow, Jason T. Parrish; Ohio State University, Columbus, OH (116)

†Emergence Pattern of Horseweed (*Conyza canadensis*); Behavior as Both a Winter and Summer Annual. Joseph D. Bolte*, Reid Smeda; University of Missouri, Columbia, MO (117)

†Emergence, Growth, and Fecundity of Palmer Amaranth in Michigan Corn and Soybeans. Jonanthon R. Kohrt*, Christy L. Sprague, Karen A. Renner; Michigan State University, East Lansing, MI (118)

†Emergence Patterns of Waterhemp and Palmer amaranth under No-Till and Tillage Conditions in Southern Illinois. Lucas X. Franca*[1], Bryan Young[2], Julie M. Young[3], Joseph L. Matthews[3]; [1]Southern Illinois University Carbondale, Carbondale, IL, [2]Purdue University, W. Lafayette, IN, [3]Southern Illinois University, Carbondale, IL (119)

†Seed-Bank Depletion and Emergence Patterns of Giant Ragweed in Various Crop Rotations. Jared J. Goplen*[1], Jeffrey L. Gunsolus[2], Craig C. Sheaffer[2], Roger L. Becker[2], Jeffrey A. Coulter[2], Fritz Breitenbach[2], Lisa Behnken[2], Gregg A. Johnson[2]; [1]University of Minnesota, Saint Paul, MN, [2]University of Minnesota, St. Paul, MN (120)

†Biological Response of Foreign Palmer Amaranth (*Amaranthus palmeri*) Biotypes in Indiana. Douglas J. Spaunhorst*, William G. Johnson; Purdue, West Lafayette, IN (121)

†Seed production of common waterhemp (*Amaranthus rudis*) is affected by time of emergence. Heidi R. Davis*, Reid Smeda; University of Missouri, Columbia, MO (122)

†Growth response of glyphosate-resistant giant ragweed (*Ambrosia trifida*) to water stress. Simranpreet Kaur*[1], Jatinder S. Aulakh[2], Amit J. Jhala[3]; [1]University of Nebraska Lincoln, Lincoln, NE, [2]University of Nebraska- Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (123)

†Cover crops in edamame: Balancing crop emergence with weed suppression. Laura E. Crawford*[1], Martin M. Williams II[2], Samuel E. Wortman[1]; [1]University of Illinois, Urbana, IL, [2]USDA-ARS, Urbana, IL (124)

†Cereal Rye Cover Crop Effects on Common Waterhemp and Common Lambsquarters Emergence. Meaghan Anderson*, Robert Hartzler; Iowa State University, Ames, IA (125)

†Effect of Inoculum Concentration of *Clavibacter michiganensis* subsp. *nebraskensis* on Infection of Alternative Hosts. Taylor M. Campbell*[1], Joseph T. Ikley[1], William G. Johnson[2], Kiersten A. Wise[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (126)

†Herbicide carryover evaluation in cover crops following silage corn and soybean herbicides. Daniel H. Smith*, Elizabeth J. Bosak, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (127)

†Mechanism of resistance in 2,4-D-resistant waterhemp. Lacy J. Leibhart*[1], Amar S. Godar[2], Mithila Jugulam[2], Zac J. Reicher[1], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (128)

†Distribution of glyphosate-resistant kochia in south-western Nebraska. Spencer L. Sameulson*[1], Bruno Canella Vieira[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (129)

†Distribution of glyphosate-resistant Palmer amaranth in south-western Nebraska. Bruno Canella Vieira*[1], Spencer L. Sameulson[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (130)

Weed management in strip tillage. Erin Haramoto*[1], Daniel Brainard[2]; [1]University of Kentucky, Lexington, KY, [2]Michigan State University, East Lansing, MI (174)

Impact of PRE+POST vs. POST-only Weed Management Strategy on N_2O Emissions. Rebecca R. Bailey*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (175)

Impact of waterhemp emergence date on growth and development of five populations in Indiana. Joseph M. Heneghan*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (176)

Weed Control in Edamame. Bernard H. Zandstra*, Colin J. Phillippo; Michigan State University, East Lansing, MI (177)

Weed Control in Vegetable Crops with bicyclopyrone. Colin J. Phillippo*, Bernard H. Zandstra; Michigan State University, East Lansing, MI (178)

Does Heterozygosity of Herbicide-Resistance Traits Deserve Greater Attention from Weed Scientists? A Case Study from Resistance to PPO Inhibitors. R. Joseph Wuerffel*[1], Bryan Young[2]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN (179)

An update on HPPD-resistance in AMAPA and AMATA populations. Vinod K. Shivrain*[1], Cheryl L. Dunne[2], Gordon Vail[1]; [1]Syngenta, Greensboro, NC, [2]Syngenta, Vero Beach, FL (180)

Molecular analysis of glyphosate resistance in giant ragweed. Karthik Ramaswamy Padmanabhan*[1], Kabelo Segobye[2], Michael Gribskov[1], Burkhard Schulz[1], Stephen C. Weller[1]; [1]Purdue University, West Lafayette, IN, [2]Botswana College of Agriculture, Gaborone, Botswana (181)

Susceptibility of Multiple Kochia (Kochia scoparia) Populations to Dicamba. David A. Brachtenbach*[1], Phillip W. Stahlman[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (182)

Equipment and Application Methods

†Impact of applications of dicamba and dicamba plus glyphosate using air-induction nozzles on glyphosate-resistant kochia. Cody F. Creech*[1], William E. Bagley[2], Ryan S. Henry[1], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (86)

†Herbicide Efficacy on Glyphosate Resistant Palmer Amaranth (*Amaranthus palmeri*) and Common Waterhemp (*Amaranthus rudis*) as Influenced by Spray Nozzle Design. Travis R. Legleiter*[1], William G. Johnson[2], Bryan Young[3]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN, [3]Purdue University, W. Lafayette, IN (87)

†Linking droplet size and deposition from Coarse nozzles in a wind tunnel. J Connor Ferguson*[1], Chris C. O'Donnell[1], Greg R. Kruger[2], Andrew J. Hewitt[1]; [1]The University of Queensland, Gatton, Australia, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (88)

†Impact of applications of dicamba and dicamba plus glyphosate using air-induction nozzles on glyphosate-resistant waterhemp. Rafael Pieroni Catojo*[1], Cody F. Creech[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (89)

†The influence of nozzle type on the performance of PPO herbicides for POST soybean applications. Camila de Carvalho Ozorio*[1], Cody F. Creech[1], Ryan S. Henry[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (90)

†Efficacy of dicamba and dicamba plus glyphosate applications with and without drift control adjuvants through four venturi-type nozzles. Leon Cimo*[1], Cody F. Creech[1], Ryan S. Henry[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (91)

†Droplet retention on soybean leaves as influlenced by nozzle type, application pressure, and adjuvant. Maximila Miranda Martins*[1], Cody F. Creech[1], Ryan S. Henry[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (92)

Comparison of four venturi nozzles on injury of tomato from 2,4-D applications. Cody T. Dorn*[1], Danilo Pavani Correa[1], Jeffrey A. Golus[1], Ryan S. Henry[1], Cody F. Creech[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (93)

Ground spray 2.0 – An improved droplet size calculator. Jeffrey A. Golus*[1], Ryan S. Henry[1], Lowell D. Sandell[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (94)

†Evaluation of spray particle size, spray pattern uniformity, and droplet velocity of four ground nozzles. Ryan S. Henry*[1], Bradley K. Fritz[2], Clint W. Hoffmann[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA-ARS, College Station, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (95)

†An evaluation of a hooded sprayer for pesticide drift reduction. Strahinja Stepanovic*[1], Ryan S. Henry[2], Steven Claussen[3], Greg R. Kruger[4]; [1]University of Nebraska-Lincoln, Grant, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Willmar Fabrication, Wilmar, MN, [4]University of Nebraska-Lincoln, USA, Lincoln, NE (96)

†Tank mixtures of glyphosate or glufosinate with growth regulators. Sjdjan Cirovic*[1], Ryan S. Henry[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, NORTH PLATTE, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (97)

†Influence of nozzle type and wind speed on tomato injury from dicamba applications. Ryan S. Henry*[1], Cody F. Creech[1], Sanela Milenkovic[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (139)

†Influence of Spray Nozzle Design on Spray Solution Deposition on Palmer Amaranth (*Amaranthus palmeri*) and Common Waterhemp (*Amaranthus rudis*). Travis R. Legleiter*[1], William G. Johnson[2], Bryan Young[3]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN, [3]Purdue University, W. Lafayette, IN (140)

†Effect of Foliar Fertilizers and Water ph on Weed Control with MON 76783, Enlist Duo, and Glufosinate. Pratap Devkota*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (141)

†Glyphosate canopy penetration in corn and soybean as influenced by nozzle type, carrier volume, and drift control adjuvant. Cody F. Creech*[1], Ryan S. Henry[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (142)

†Which adjuvants increase glufosinate efficacy? Theresa A. Reinhardt*, Rich Zollinger, Kirk Howatt, Devin A. Wirth; North Dakota State University, Fargo, ND (143)

†Marketability and Seed Production Effects from Glyphosate Drift Injury to Red Norland Potato. Amanda Crook*[1], Harlene M. Hatterman-Valenti[2], Collin Auwarter[1]; [1]NDSU, Fargo, ND, [2]North Dakota State University, Fargo, ND (144)

†Alternative Weed Control Options During Vineyard Establishment in North Dakota. John E. Stenger*[1], Collin P. Auwarter[2], Harlene M. Hatterman-Valenti[1]; [1]North Dakota State University, Fargo, ND, [2]ndsu, fargo, ND (145)

†Utilizing R software for response surface data analysis in application technology and weed science. Strahinja Stepanovic*[1], Ryan S. Henry[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Grant, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (146)

Application best management practices for balancing drift mitigation and weed control with the Enlist Weed Control System. Andy Asbury*[1], Patrick Havens[2], David E. Hillger[3], Ryan Keller[4], John Laffey[5], Ralph Lassiter[6], Jerome Schleier[2], Jonathan Siebert[7]; [1]Dow AgroSciences, Dahinda, IL, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Noblesville, IN, [4]Dow AgroSciences, Rochester, MN, [5]Dow AgroSciences, Maryville, MO, [6]Dow AgroSciences, Raleigh, NC, [7]Dow AgroSciences, Greenville, MS (165)

Influence of nozzle type and wind speed on soybean injury from dicamba applications. Ryan S. Henry*[1], Cody F. Creech[1], Sanela Milenkovic[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (166)

Influence of nozzle type and wind speed on cotton injury from dicamba applications. Ryan S. Henry*[1], Cody F. Creech[1], Sanela Milenkovic[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (167)

Implications of drift studies on the application of herbicides: A review of what we have learned. Greg R. Kruger*[1], Ryan S. Henry[2], William E. Bagley[3]; [1]University of Nebraska-Lincoln, USA, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Bagley Enterprises, San Antonio, TX (168)

Assessment of Drift Reduction Technologies and Pulse Width Modulation for Dicamba-Glyphosate Applications on Glyphosate Resistant Waterhemp. Scott M. Bretthauer*[1], Robert E. Wolf[2], Matthew P. Gill[1]; [1]University of Illinois, Urbana, IL, [2]Wolf Consulting and Research, Mahomet, IL (169)

Atomization of Agricultural Tank Mixtures Using a Pulse Width Modulation Spray Delivery System: Part II. Lillian C. Magidow*[1],Stephanie Wedryk[2]; [1]Winfield Solutions, River Falls, WI, [2]Winfield Solutions, St. Paul, MN (170)

LAESI-MS in the Determination of 2,4-Dichlorophenoxyacetic Acid in Plant Tissue. Gregory J. Lindner*[1], Stephen Rumbelow[2], Holly Henderson[3], Melissa Moury[3], Haddon Goodman[3], Thomas Steen[1]; [1]Croda Inc, New Castle, DE, [2]Croda Inc, Wilmington, DE, [3]Protea Biosciences, Morgantown, WV (171)

Glufosinate Efficacy with Tank-mix Partners and Droplet Size. Kirk A. Howatt*[1], Rich Zollinger[2]; [1]NDSU, Fargo, ND, [2]North Dakota State University, Fargo, ND (172)

Ammonium sulfate replacement adjuvants - Part 3. Rich Zollinger*[1], Kirk Howatt[1], Bryan Young[2], Mark Bernards[3]; [1]North Dakota State University, Fargo, ND, [2]Purdue University, W. Lafayette, IN, [3]Western Illinois University, Macomb, IL (173)

Cover Crops

Cover crop trends in the United States. Erin C. Hill*; Michigan State University, East Lansing, MI (147)

Cover crop and herbicide interactions: A Michigan perspective. Erin C. Hill*, Christy L. Sprague, Karen A. Renner; Michigan State University, East Lansing, MI (148)

Cover crop adoption and utilization in the mid-Atlantic; a combination of staunch enthusiasm and anxious uncertainty. William Curran*[1], Dwight D. Lingenfelter[2]; [1]Penn State, University Park, PA, [2]Penn State University, University Park, PA (149)

Cover Crop Research and Extension Needs in Northern Midwest Farming Operations. Elizabeth J. Bosak*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (150)

Potential for Herbicide Residues to Impact Cover Crop Establishment and Function. Darren Robinson*; University of Guelph, Ridgetown, ON (151)

Soil-Applied Herbicides over Spring Seeded Cover Crops. Thomas J. Peters*, Aaron L. Carlson; North Dakota State University, Fargo, ND (152)

Roadmap to Success: The Human Dimension of Managing Herbicide Resistance

Herbicide resistant weeds - efforts and endeavors past, present and future. Micheal D. Owen*; Iowa State University, Ames, IA (193)

Iowa Farmers' Perspectives on Herbicide Resistance. J G. Arbuckle*; Iowa State University, Ames, IA (194)

Knocking Down Economic Barriers to Herbicide Resistance Management. Terrance M. Hurley*; University of Minnesota, St. Paul, MN (195)

How Micro and Macro Social Forces May be Influencing Farmer Response to the."Wicked Problem" of Herbicide Resistant Weeds. Raymond A. Jussaume*; Michigan State University, East Lansing, MI (196)

Addressing several barriers to diversification of weed management by revealing the hidden costs of biological time constraints. Jeffrey L. Gunsolus*; University of Minnesota, St. Paul, MN (197)

[1] ***PRESENTER** **† STUDENT CONTEST**

Abstracts

ENLIST CORN WEED CONTROL SYSTEMS IN MIDWEST. David C. Ruen*[1], Mike M. Moechnig[2], Eric F. Scherder[3], Kristin Rosenbaum[4], Laura A. Campbell[5], Fikru Haile[6], Leah L. Granke[7], Jeff M. Ellis[8]; [1]Dow AgroSciences, Lanesboro, MN, [2]Dow AgroSciences, Toronto, SD, [3]Dow AgroSciences, Huxley, IA, [4]Field Scientist, Crete, NE, [5]Dow AgroSciences, Carbondale, IL, [6]Dow AgroSciences, Carmel, IN, [7]Dow AgroSciences, Columbus, OH, [8]Dow AgroSciences, Smithville, MO (1)

No abstract submitted

ACURON: A NEW RESIDUAL HERBICIDE WITH FOUR ACTIVE INGREDIENTS FOR BROAD-SPECTRUM WEED CONTROL IN CORN. Mason Adams*[1], Debalin Sarangi[1], Aaron S. Franssen[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Syngenta Crop Protection, Seward, NE (2)

Acuron™, a new broad-spectrum corn herbicide, is a prepackaged mixture of four active ingredients (atrazine, bicyclopyrone, mesotrione, and S-metolachlor) that provides three modes of action. The formulation will contain a safener, benoxacor, and its application timing will be from 28 days preplant up to 30-cm corn. A field experiment was conducted in Clay County, NE in 2014 to evaluate the efficacy of Acuron applied pre-emergence (PRE) for control of grasses and small-seeded broadleaf weeds and to compare efficacy with commonly used PRE herbicides in corn. Results suggested that Acuron applied PRE alone at 2,890 g ai ha^{-1} or tank-mixed with atrazine provided ≥ 97% control of broadleaf weeds, including common waterhemp, common lambsquarters, and velvetleaf and grass weeds such as crabgrass and yellow foxtail throughout the growing season. All herbicide treatments resulted in >80% weed control at 60 days after treatment; however, residual activity reduced later in the season. For example, common waterhemp control was ≤ 84% at harvest in the treatments including acetochlor plus clopyralid plus flumetsulam (Surestart), saflufenacil plus dimethenamid-P (Verdict), or thiencarbazone-methyl plus isoxaflutole (Corvus) compared to 99% control with Acuron treatments. Similar results were observed for control of velvetleaf and common lambsquarters, while grass weed control was usually comparable in all herbicide treatments. The experiment will be repeated in 2015 growing season to confirm results.

ANOTHER ALS-RESISTANT SPECIES: COMMON CHICKWEED AND ITS CONTROL. Dwight D. Lingenfelter*[1], William Curran[2]; [1]Penn State University, University Park, PA, [2]Penn State, University Park, PA (3)

From 2010 to 2013, fall- and spring-applied herbicides were evaluated to determine their impact on control of suspected ALS-resistant common chickweed (Stellaria media) in winter small grain fields in southeastern Pennsylvania. Treatments were applied in late October to mid-November (chickweed – 15-23 cm in diameter) and mid-March to late March (chickweed – 30 cm in diameter) with a hand-held boom sprayer that delivered 187 L ha-1. Thifensulfuron plus tribenuron premix was applied at 31.4 g ai ha^{-1}; fluroxypyr at 69.4 and 121 g ha^{-1}; metribuzin at 105, 157, and 211 g; 2,4-D at 398 g ha^{-1}; dicamba at 140 g ha^{-1}; fluroxypyr plus dicamba premix at 183 g ha^{-1}; pyrasulfotole plus bromoxynil premix at 266 g ha^{-1}; pyroxsulam at 18.4 g ha^{-1}; and mesosulfuron at 15 g ha^{-1}. Some of these treatments were applied as a single active ingredient while others were tank-mixed or applied in sequence. All treatments contained the recommended adjuvants. Plots were replicated and randomized and measured 3 m wide by 9 m long. Ratings taken in late April/early May revealed that the chickweed population was ALS-resistant, since the thifensulfuron plus tribenuron premix provided no more than 70% control when applied in the fall and less than 37% when applied during the spring. Also pyroxsulam, another ALS-inhibiting herbicide, only provided 77% control when fall-applied. Treatments containing fluroxypyr provided 92-98% chickweed control when applied in the fall and 84-99% control when applied in the spring. In general, metribuzin alone or in combination provided greater than 90% chickweed control, regardless of rate or application timing. A tank-mixture of 2,4-D plus dicamba provided chickweed control ranging from 67 to 89%; whereas the pyrasulfotole plus bromoxynil premix ranged from 32 to 80% control. Fall-applied herbicide generally provided more consistent control of common chickweed. Metribuzin and fluroxypyr provide the most effective control of ALS-resistant common chickweed. Currently, metribuzin has a 24(c) supplemental label for use in wheat and barley in the Mid-Atlantic region, however potential crop injury has been evident on certain winter wheat and barley varieties. Fluroxypyr has good crop safety, but has a limited weed control spectrum. The thifensulfuron plus tribenuron premix still provides adequate control of other common weeds found in Pennsylvania small grains, thus using it in combination with other herbicides will likely occur in order to obtain broad-spectrum control while maintaining an economical solution. Pyroxsulam and mesosulfuron also are used to control certain grassy weeds such as annual and roughstalk bluegrass and annual brome species but would need to be tank-mixed to control chickweed and broaden the control spectrum. Crop rotation and the use of other weed control tactics including different herbicide programs and modes of action provides the most reliable means of controlling ALS-resistant common chickweed. The ALS-resistant chickweed populations are primarily located in the southeastern part of Pennsylvania and not yet widespread across the state but have been documented in neighboring states to the south.

POPCORN, SWEET CORN AND FIELD CORN INBRED TOLERANCE TO PREEMERGENCE AND POSTEMERGENCE ACURON APPLICATIONS. Tim Trower*[1], Gordon Vail[2], Ryan D. Lins[3], Tom Beckett[2]; [1]Syngenta, Baraboo, WI, [2]Syngenta, Greensboro, NC, [3]Syngenta, Byron, MN (4)

No abstract submitted

SEQUENTIAL HERBICIDE EVALUATION IN GLUFOSINATE-RESISTANT CORN IN WISCONSIN. Devin J. Hammer*, Rebecca R. Bailey, Thomas R. Butts, Daniel H. Smith, Elizabeth J. Bosak, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (5)

Weed control, especially through the critical weed-free period, is important for maximizing corn yield. Additionally, achieving weed control through diversified herbicide site-of-action combinations helps prevent resistance evolution by reducing selection pressure. Moreover, when season-long weed control is obtained, crops have the best chance to produce their full yield potential and weed seed production is reduced. The greatest recent concerns regarding herbicide resistance in much of the Midwest is from the over-reliance on the postemergence (POST) use of glyphosate. To generate recommendations for herbicide diversity in corn [*Zea mays*], a trial was conducted in 2013 – and repeated in 2014 – to evaluate postemergence glufosinate based programs at the University of Wisconsin Arlington Agriculture Research Station. The objective of this study was to compare weed efficacy of POST glufosinate applications following preemergence (PRE) herbicide application in corn. There were 23 treatments evaluated which included a nontreated check for comparison. Among the treatments, there were one-pass PRE applications, one-pass early postemergence (EPOST) applications, and PRE+POST applications. All herbicides were applied with the recommended rates and surfactants. Control ratings were taken visually on a scale of 0-100 where 0 represented no control and 100 represented complete plant death. Ratings were collected each season starting the first week after the PRE application. The four main weed species evaluated were common lambsquarters [*Chenopodium album*], velvetleaf [*Abutilon theophrasti*], common ragweed [*Ambrosia artemisiifolia*], and giant foxtail [*Setaria faberi*]. The PRE+POST applications had better control for all weed species 2-3 weeks after the POST application (5-6 weeks after PRE application) compared to one-pass PRE programs ($P < 0.0001$). However, the EPOST treatments yielded 456.1 kg ha^{-1} more than the PRE+POST programs ($P = 0.0377$) and 497.7 kg ha^{-1} more than the one-pass PRE programs ($P = 0.0129$). Also, between the PRE+POST and EPOST programs there were no significant differences in control of common ragweed ($P = 0.5585$) or velvetleaf ($P=0.3136$). The PRE+POST programs did have significantly better control of common lambsquarters and giant foxtail than the EPOST treatments ($P < 0.0001$ and $P = 0.0001$, respectively). From an agronomic standpoint the data shows that using an EPOST program will gain you higher yields due to timing of application. However, by using diversified herbicide applications there is an opportunity to reduce selection pressure for resistance evolution in weed populations.

ACURON HERBICIDE: BURNDOWN AND RESIDUAL WEED CONTROL IN NO-TILL CORN. Scott E. Cully*[1], Nicholas A. Frederking[1], Thomas H. Beckett[2], Gordon Vail[2]; [1]Syngenta, Marion, IL, [2]Syngenta, Greensboro, NC (6)

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

CONFIRMATION AND CHARACTERIZATION OF ALS-INHIBITOR RESISTANCE IN HENBIT (*LAMIUM AMPLEXICAULE*). Vijay K. Varanasi*[1], Amar S. Godar[1], Dallas E. Peterson[1], Doug Shoup[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University - Southeast Area Extension Office, Chanute, KS (7)

Henbit (*Lamium amplexicaule* L.) is a facultative winter annual broadleaf weed that belongs to the mint family (Lamiaceae). The emergence and spread of winter annual weeds such as henbit in the U.S. has increased with the adoption of conservation tillage cropping systems. ALS (acetolactate synthase)-inhibitors are primary herbicides used for broadleaf weed control in winter wheat. During 2013-2014 season, field applications of ALS-inhibiting herbicides were ineffective in controlling a henbit population from Marion County, Kansas (MCK). In a greenhouse experiment, progeny of the MCK population was treated with three different families of ALS-inhibitors: chlorsulfuron (SU), imazamox (IMI), and propoxycarbazone (SCT). Chlorsulfuron and propoxycarbazone were applied to MCK plants at doses of 0, 0.5, 1, 2, 4, 8, 16, and 32X, whereas susceptible (S) plants were treated with 0, 0.03, 0.06, 0.13, 0.25, 0.5, 1, and 2X, respectively. Results of dose-response experiments suggest that the MCK population is resistant to chlorsulfuron (R/S = 43) and propoxycarbazone (R/S = 26.9), but susceptible to imazamox (at 1 and 4X rates). Furthermore, to understand if ALS-inhibitor resistance in the MCK population has evolved as a result of mutation in the target gene, a 5' and 3' RACE (Rapid Amplification of cDNA Ends) approach was used to obtain the *ALS* gene sequences. A known $proline_{197}$ arginine point mutation conferring resistance to SU's was found in the resistant MCK population. Efforts are currently underway to obtain the 3' region of the *ALS* gene to determine the target site mutation conferring resistance to propoxycarbazone. Even though the MCK population can be controlled by IMIs, resistance to other ALS-inhibitors will reduce control options during the crop growing season. To our knowledge this is the first reported case of herbicide resistance in henbit.

SYN-A205: A TECHNICAL OVERVIEW. Scott Payne*[1], Ryan D. Lins[2], Gordon Vail[3], Tom Beckett[3]; [1]Syngenta, Slater, IA, [2]Syngenta, Byron, MN, [3]Syngenta, Greensboro, NC (8)

SYN-A205 is a multiple mode-of-action herbicide premix that provides preemergence and early postemergence control of grass and broadleaf weeds in corn. SYN-A205 will be labeled for preemergence and postemergence use in field corn and seed corn and for preemergence use only in sweet corn, and yellow popcorn. SYN-A205 contains mesotrione, *S*-metolachlor, and bicyclopyrone, a new triketone HPPD (4-hydroxyphenyl-pyruvate dioxygenase) inhibitor, with anticipated first commercial applications in the 2016 growing season. Field trials demonstrate that SYN-A205 is safe when applied to field corn, seed corn, sweet corn and yellow popcorn. SYN-A205 is effective on difficult-to-control weeds, including giant foxtail (*Setaria faberi*), common lambsquarters (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*), Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus rudis*) with improved residual control and consistency compared to commercial standards.

ACURON RESIDUAL WEED CONTROL. Adrian Moses*[1], Gordon Vail[2], Scott Cully[3], Tom Beckett[2]; [1]Syngenta, Ames, IA, [2]Syngenta, Greensboro, NC, [3]Syngenta, Marion, IL (9)

Residual weed control of Acuron was compared to other premixes in trials. Preemergence applications were evaluated against difficult to control weeds.

CARRYOVER OF COMMON CORN AND SOYBEAN HERBICIDES TO VARIOUS COVER CROP SPECIES IN MISSOURI. CODY D. CORNELIUS, JAIME FARMER, MANDY BISH, ALEX LONG, MEGHAN BIGGS, AND KEVIN BRADLEY. Cody D. Cornelius*[1], Jaime Farmer[2], Mandy D. Bish[3], Alex R. Long[4], Meghan E. Biggs[4], Kevin W. Bradley[4]; [1]University of Missouri, Columbia MO, MO, [2]University of Missouri-Columbia, Columbia, MO, [3]University of Missouri, 65211, MO, [4]University of Missouri, Columbia, MO (10)

The recent interest in cover crops as a component of Midwest corn and soybean production systems has led to the need for additional research, including the effects of residual corn and soybean herbicide treatments on fall cover crop establishment. Field studies were conducted in 2013 and 2014 to investigate the effects of common residual herbicides applied in corn and soybean on establishment of winter wheat, tillage radish, cereal rye, crimson clover, winter oat, Austrian winter pea, Italian ryegrass, and hairy vetch. Following removal of the previous corn or soybean crop for forage, each cover crop species was planted on September 11 and 10 in 2013 and 2014, respectively. The experimental design was a split-plot arrangement of treatments with four replications. Whole plots consisted of herbicide treatments while subplots were cover crop species. In general, more herbicide carryover injury occurred to cover crops in 2013 than 2014. This is most likely due to the greater amount of rainfall that occurred in 2014; 66.8 cm was received from April through September of 2013 while 2014 had 91.6 cm of rainfall during this same time period. Of all the cover crop species evaluated, tillage radish was most affected by previous herbicide residues. In 2013, soybean herbicide treatments that contained fomesafen, imazethapyr, or *S*-metolachlor plus fomesafen resulted in stand and biomass reductions of tillage radish by 28 days after emergence (DAE). These treatments reduced tillage radish density by 10 to 17 plants per m^2 and reduced tillage radish biomass by approximately 50% compared to the non-treated control. Differences in tillage radish density and biomass reduction was less noticeable in 2014 with the exception of the *S*-metolachlor plus fomesafen treatment, which resulted in a stand loss of 15 plants per m^2. Winter oats and Italian ryegrass were both affected by pyroxasulfone treatment in 2013 corn and soybean trials. Compared to the non-treated control, winter oats were reduced by 39 to 93 plants per m^2 and Italian ryegrass by 188 to 271 plants per m^2 in the corn and soybean experiments. However, no differences in winter oat or Italian ryegrass densities were observed in response to pyroxasulfone residues in 2014. For both 2013 and 2014, three corn herbicide programs, atrazine, rimsulfuron, and tembotrione, resulted in no stand loss for any of the cover crops in this study when compared to the non-treated control. Similarly the cloransulam, metribuzin, and sulfentrazone soybean treatments resulted in no stand loss for any of the cover crops in this study across both years.

THE IMPACT OF FALL-PLANTED COVER CROP MONOCULTURES AND SIMPLE MIXTURES ON WEED PRESENCE IN CORN. Victoria J. Ackroyd*[1], Christy L. Sprague[2]; [1]Michigan State University, 48824, MI, [2]Michigan State University, East Lansing, MI (11)

Cover crops are an increasingly common feature of crop production systems in the Midwest. Growers have expressed particular interest in cover crop mixtures, especially those which include oilseed radish. A three-year field study was conducted from 2011-2014 at Michigan State University (East Lansing, MI) to investigate the performance of cover crop pure stands and two-species cover crop mixtures and their impact on weed presence when planted after wheat. Cover crop treatments included pure stands of oilseed radish, annual ryegrass, cereal rye, oats, crimson clover, hairy vetch, and winter pea. Two-species mixtures included oilseed radish as the common-denominator species, paired with each of the other cover crops. The oilseed radish was planted at the same rate in both pure stand and mixture treatments; the other cover crops were planted at half the pure stand rate when included as part of a mixture treatment. Bare-fallow and weedy controls were also included as treatments. Cover crops were no-till planted in August following wheat harvest. Cover crop and weed biomass was collected and separated 8-10 weeks after planting and again in the spring immediately prior to termination of surviving cover crops. Field corn was planted after cover crop termination and tillage. None of the data sets could be combined due to significant treatment*year interactions. In most years, pure stand legume treatments had some of the lowest cover crop fall biomass and highest weed biomass. Treatments that included oilseed radish generally had lower fall weed biomass than other treatments; oilseed radish comprised the majority of the cover crop biomass in mixture treatments. As expected, oilseed radish and oats failed to overwinter all three years. Legume cover crop treatments performed the most erratically over the course of the study (e.g., winter pea failed to overwinter in two of the three study years). The cereal rye and cereal rye + radish treatments consistently had some of the highest cover crop and lowest weed biomass production each spring. Cover crops and cover crop mixtures, especially those including a grass or oilseed radish, can effectively suppress fall weeds. Some of this weed suppression may carry over into the spring. However, cover crop biomass production can be unreliable due to poor establishment and winter weather conditions, which may help to explain the erratic nature of the weed suppression results.

DOSE RESPONSE OF SELECTED GLYPHOSATE-RESISTANT WEEDS TO PREPACKAGED MIXTURE OF FLUTHIACET-METHYL AND MESOTRIONE APPLIED AT TWO GROWTH STAGES. Zahoor A. Ganie*[1], Gail Stratman[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]FMC Corporation, Stromsburg, NE (12)

Management of glyphosate-resistant weeds is a tough challenge for crop producers in Nebraska and other states in the United States. Herbicide mixtures with different effective modes of action has been reported as one method for controlling herbicide-resistant weeds. A prepackaged mixture of fluthiacet-methyl and mesotrione (1:17.5 ratio) has recently been registered for POST broadleaf weed control in corn. The objective of this study was to determine the response of glyphosate-resistant common waterhemp, giant ragweed, and kochia to prepackaged mixture of fluthiacet-methyl plus mesotrione when applied to 10- and 20-cm tall plants. Greenhouse dose response studies were conducted and log-logistic models were used to determine the response and the rate of fluthiacet-methyl plus mesotrione required to provide 50% (ED_{50}) and 90% (ED_{90}) control of selected glyphosate-resistant weeds. The response and the effective rate required to achieve acceptable control varied depending on the weed species and its growth stage. The rates of fluthiacet-methyl plus mesotrione required for 90% control (ED_{90}) of 10-cm tall common waterhemp, giant ragweed, and kochia were 78, 251, and 17 g ai ha^{-1}, respectively, compared to 144, 489, and 79,349 g ai ha^{-1}, respectively, for 20-cm tall plants at 21 d after treatment (DAT). Irrespective of weed species or growth stage, the ED_{90} values calculated on the basis of percent dry weight reduction were mostly higher compared to visual control estimates at 21 DAT. Kochia at 10 cm height, was the most sensitive to this prepackaged herbicide mixture followed by common waterhemp, while giant ragweed was the least sensitive. It is concluded that prepackaged mixture of fluthiacet-methyl plus mesotrione can be potentially used as a POST herbicide in corn for controlling glyphosate-resistant common waterhemp and kochia at the labeled rate (87 g ai ha^{-1}), but a higher rate would be required to achieve 90% control of glyphosate-resistant giant ragweed. However, the more appropriate recommendations can be made on the basis of dose response studies conducted under the field conditions.

SWEET CORN AND POPCORN TOLERANCE TO POSTEMERGENCE APPLICATIONS OF NICOSULFURON + MESOTRIONE + ISOXADIFEN-ETHYL. Danielle R. Cooney*[1], Larry H. Hageman[2], Helen L. Flanigan[3], Scott E. Swanson[4]; [1]University of Illinois, Urbana, IL, [2]DuPont, ROCHELLE, IL, [3]DuPont, Johnston, IA, [4]DuPont, Rochelle, IL (13)

A field study was conducted at the DuPont Rochelle, Illinois Midwest Field Research Station to evaluate the effects of spraying sweet corn and popcorn hybrids with a postemergence safener + sulfonylurea + mesotrione herbicidal combination alone or following a preemergence application of *S*-metolachlor. Seven of the eight sweet corn and the eight popcorn hybrids suffered little to no injury from the postemergence application of the safened herbicide combination of nicosulfuron + mesotrione + isoxadifen-ethyl alone or following a preemergence application of S-metolachlor, with or without atrazine, at 7, 14 or 28 days after postemergence treatment. As expected, a sulfonylurea sensitive sweet corn hybrid, 'Merit', had little to no tolerance to these herbicidal treatment combinations. All herbicidal treatments provided complete control of velvetleaf, redroot pigweed, giant foxtail and barnyardgrass in this trial at 28 DAT. Results from this field trial would strongly suggest that nicosulfuron + mesotrione + isoxadifen-ethyl (Revulin™ Q) is safe for use on these specific sweet corn and popcorn hybrids evaluated in this field trial and this combination will provide excellent broad spectrum weed control.

ALS-INHIBITING HERBICIDE DOSE AND PLANT SIZE INFLUENCE THE CONTROL OF ALS-RESISTANT SHATTERCANE POPULATIONS. Rodrigo Werle*[1], Roberto L. Martins[2], Lowell D. Sandell[3], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]São Paulo State University, Botucatu, Brazil, [3]Valent USA Corporation, Lincoln, NE (14)

Traditional breeding technology is currently being used to develop grain sorghum germplasm that will be tolerant to acetolactate synthase (ALS)-inhibiting herbicides. Use of ALS-inhibitors for weed control during the 1980's and 1990's resulted in the evolution of resistance to ALS-inhibitors in shattercane, a weedy relative of sorghum. A recent survey conducted with shattercane populations from Nebraska and Kansas revealed that ALS-resistant shattercane populations are still present in corn-soybean production systems. The presence of ALS-resistant shattercane populations and gene flow from crop to weed are the major concerns regarding the introduction of this new technology. The objective of this study was to evaluate the response of several shattercane populations to nicosulfuron applied at different rates and plant growth stages. Six shattercane populations were selected from the aforementioned survey (2 resistant, 2 intermediate, and 2 ALS-susceptible populations). ALS-tolerant and susceptible sorghums were included as controls. Plants were grown under greenhouse conditions in square plastic pots (13 cm wide and 15 cm high) filled with commercial potting mix. The study was arranged in a randomized complete block design with four replications and was conducted twice. Three planting times were scaled at 2 week intervals. At 2 weeks after the last planting time, plants were treated with 0, 0.5, 1 or 2 times the recommended nicosulfuron rate (35 g ai ha^{-1}). Plants from the first, second, and third planting time were, on average, at V7 (V6-V8; 92±4 cm; average ± standard error), V4 (V4-V5; 46±1 cm), and V1 (V1-V2; 14±1 cm) growth stage, respectively, at herbicide application time. Visual evaluation data (on a scale of 1 to 10, with 1 being dead and 10 being completely healthy) were collected at 21 days after treatment. Plants with visual evaluations ranging from 1-3, 3-8 and 8-10 were considered susceptible, intermediate and resistant, respectively. A three-way interaction between population, growth stage and herbicide rate was detected ($P<0.01$); therefore, the response of each population to each herbicide rate and plant growth stage combination was evaluated separately. When applied at V7, herbicide treatments were not very effective, even on susceptible populations. When treated at V4, plants from the susceptible populations were completely controlled but intermediate and resistant populations were not. When treated at V1, susceptible populations were controlled, intermediate populations had significant reduction in plant development and resistant populations had their level of resistance lowered when using the recommended herbicide rate. When a 2X rate was used at V1 better weed control was achieved but crop injury was also observed. Nicosulfuron application at young growth stages using the labeled rate resulted in adequate control of susceptible shattercane populations and lowered the resistance level of intermediate and resistant populations. According to our results, early weed control is likely to reduce competition with crop and also the spread of resistance in subsequent cropping seasons (by reducing fitness of resistant biotypes). Molecular work will be conducted to further explore the underlying cause of ALS-resistance in the shattercane populations used in this study.

VOLUNTEER GLYPHOSATE AND GLUFOSINATE RESISTANT CORN COMPETITIVENESS AND CONTROL IN GLYPHOSATE AND GLUFOSINATE RESISTANT CORN. Nader Soltani*, Christy Shropshire, Peter H. Sikkema; University of Guelph, Ridgetown, ON (15)

Glyphosate and glufosinate resistant (RR/LL) volunteer corn has become a problem when hybrid RR/LL corn follows hybrid RR/LL corn in the rotation. A total of six field trials were conducted over a three year period (2008 to 2010) in southwestern Ontario to a) evaluate the competitiveness of volunteer RR/LL corn in hybrid RR/LL corn, and b) determine how to control volunteer RR/LL corn in hybrid RR/LL corn. The predicted volunteer RR/LL corn density to reduce hybrid RR/LL corn yield by 5% was 1.7 volunteer RR/LL corn plants m^{-2}. There was no crop injury in hybrid RR/LL corn with herbicides evaluated at 1 and 2 WAA except for rimsulfuron (15 g ai ha^{-1}) and foramsulfuron (35 g ai ha^{-1}) which caused as much as 5 and 11% injury in hybrid RR/LL corn, respectively. Glyphosate (1800 g ae ha^{-1}), glufosinate (500 g ae ha^{-1}) and glyphosate + glufosinate (1800 + 500 g ae ha^{-1}) provided up to 18, 10 and 21% control of volunteer RR/LL corn, respectively. The POST application of rimsulfuron (15 g ai ha^{-1}), nicosulfuron (25 g ai ha^{-1}), nicosulfuron/rimsulfuron (25 g ai ha^{-1}), foramsulfuron (35 g ai ha^{-1}), and primisulfuron/dicamba (166 g ai ha^{-1}) did not provide any control of volunteer RR/LL corn. Glyphosate and glyphosate + glufosinate reduced volunteer corn density 26 and 30%, respectively. The other herbicides evaluated did not reduce volunteer RR/LL corn density compared to the weedy control. None of the herbicides evaluated reduced volunteer RR/LL corn cob numbers compared to the weedy control. Glyphosate + glufosinate applied POST reduced volunteer RR/LL corn yield 35% compared to the weedy control but other herbicides evaluated caused no reduction in volunteer RR/LL corn yield compared to the weedy control. Glyphosate applied POST resulted in hybrid RR/LL corn yield equivalent to the weed free control but all other herbicide treatments resulted hybrid RR/LL corn yield equivalent to the weedy control. This research concludes that volunteer RR/LL corn can be very competitive with RR/LL hybrid corn. None of the herbicides evaluated provided adequate control of volunteer RR/LL corn in hybrid RR/LL corn.

WEED MANAGEMENT WITH TANKMIXES OF S-METOLACHLOR, IMAZETHAPYR AND LINURON IN DRY BEAN. Nader Soltani*[1], Rob E. Nurse[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Agriculture Canada, Harrow, ON (16)

Field studies were conducted in various locations in Ontario during 2011 to 2013 to evaluate s-metolachlor, imazethapyr and linuron applied preemergence (PRE) alone and in tankmix combination for the control of troublesome weeds in kidney bean. S-metolachlor, imazethapyr, linuron, s-metolachlor + imazethapyr, s-metolachlor + linuron and s-metolachlor + imazethapyr + linuron applied PRE at rates evaluated caused 3% or less injury in kidney bean. S-metolachlor provided 87-91% control of redroot pigweed, 46-55% control of common lambsquarters, and 96-97% control of green foxtail. Imazethapyr provided 93-96% control of redroot pigweed, 96-99% control of lambsquarters and 86-93% control of green foxtail. Linuron provided 82-98% control of lambsquarters, 82-99% control of redroot pigweed and 55-85% control of green foxtail. The tankmixes of s-metolachlor plus imazethapyr, s-metolachlor plus linuron, and s-metholachlor plus imazethapyr plus linuron provided 92-100% control of lambsquarters, redroot pigweed and green foxtail. Generally, kidney bean yields reflected the level of weed control. Based on these results, tankmixes of s-metolachlor plus imazethapyr, s-metolachlor plus linuron, and s-metholachlor plus imazethapyr plus linuron all provided an adequate margin of crop safety and excellent control of redroot pigweed, common lambsquarters and green foxtail in kidney bean.

DUPONT TRIVENCE: A SECOND YEAR REVIEW OF A NEW PREEMERGENCE HERBICIDE IN SOYBEAN. Kelly Barnett*[1], Helen A. Flanigan[2], Kevin L. Hahn[3], J. Dan Smith[4]; [1]DuPont Crop Protection, Whiteland, IN, [2]DuPont, Greenwood, IN, [3]DuPont Crop Protection, Bloomington, IL, [4]DuPont Crop Protection, Madison, MS (17)

Preplant and preemergence applications that provide several weeks of effective residual control of difficult-to-control weeds are desirable for growers in the Midwest. Glyphosate-resistant weeds, in particular, are becoming increasingly difficult for growers to control. With timely rainfall or irrigation, preemergence applications with multiple modes of action can provide several weeks of residual control for glyphosate-resistant weeds such as Palmer amaranth, common and tall waterhemp, giant ragweed, and marestail (horseweed). Therefore, DuPont™ Trivence™ herbicide was developed as a new preemergence blend that includes the active ingredients chlorimuron, flumioxazin, and metribuzin to provide a new tool for controlling glyphosate-resistant weeds. Studies were implemented in 2014 to determine the residual value of Trivence™ in comparison to standard preemergence herbicides such as Boundary, DuPont™ Canopy™ herbicide + DuPont™ Cinch herbicide, DuPont™ Envive™ herbicide, and Fierce. The purpose of these studies was to evaluate the residual control provided by Trivence™ in comparison to standard preemergence herbicides and to evaluate the crop response associated with these applications. Weed control was evaluated using a scale of 0-100% for weed species such as Palmer amaranth, common waterhemp, morningglory spp., giant ragweed, common ragweed, and marestail (horseweed). In addition, crop response was evaluated after each application using a scale of 0-100% to assess crop injury associated with these applications. Experimental design was a randomized complete block design with 3 to 4 replications, depending on the location. In the first study, preemergence applications of Trivence™ and Envive™ provided the most broad-spectrum control of grass, broadleaf, and nutsedge weed species. The addition of Zidua (pyroxasulfone) to preemergence applications of Trivence™ increased control of glyphosate-resistant Palmer amaranth. The second study evaluated full program approaches with combinations of early preplant, preemergence, and post applications that included Trivence™. Early preplant applications of DuPont™ Canopy® EX herbicide followed by a PRE of Envive®, Canopy® + Cinch®, or Trivence™ (all products tank-mixed with 2,4-D and glyphosate) provided the greatest level of control of marestail (horseweed), common waterhemp, and giant ragweed. Trivence™ applied alone PRE increased control of morningglory species when compared to Canopy® + Cinch®, Envive®, Fierce, or Boundary. In either study, Trivence™ did not increase crop response when compared with other preemergence herbicides such as Canopy®, Envive®, Boundary, and Fierce. Trivence™ provided consistent control of difficult-to-control weeds such as common waterhemp, Palmer amaranth, common ragweed, horseweed (marestail), and morningglory species.

COMPARISON OF HERBICIDE AND COVER CROP UTILIZATION FOR HORSEWEED SUPPRESSION BEFORE AND DURING A SOYBEAN CROP. Andi M. Christenson*[1], J. Anita Dille[2], Kraig L. Roozeboom[1], Dallas E. Peterson[1]; [1]Kansas State University, Manhattan, KS, [2]Agronomy Department, Kansas State University, Manhattan, KS (18)

With an increasing number of herbicide-resistant weed species, it has become apparent that alternative methods of weed suppression should be examined. The objective of this study was to determine the amount of horseweed (*Conyza canadensis*) suppression that can be achieved using various cover crop and herbicide systems. Four fall cover crop treatments consisting of wheat (*Triticum aestivum*), rye (*Secale cereale*), barley (*Hordeum vulgare*) and annual rye grass (*Lolium multiflorum*) were seeded in November 2013 and November 2014. A spring cover crop treatment was seeded each year with spring oat (*Avena sativa*) planted in April 2013 or rye planted in March 2014. Other treatments included chemical fallow: plots that received fall or spring applications of Clarity (285 g ae ha^{-1} dicamba) plus Valor XLT (85 g ai ha^{-1} flumioxazin, 29 g ai ha^{-1} chlorimuron) and plots that received fall or spring applications of Clarity (71 g ae ha^{-1} dicamba) plus 2,4-D LV4 (1135 g ae ha^{-1} 2,4-D). Valor XLT and dicamba were also spring applied to plots of rye. This study also included a non-treated fallow control plot. All treatments were in sorghum stubble (*Sorghum bicolor*) in Manhattan, KS. Cover crop plots were divided in half and were terminated with a roller crimper or glyphosate application approximately one week before soybean planting. Soybeans were planted in June 2013 and May 2014, and mechanically harvested in October of both years. Horseweed populations and biomass accumulation were quantified for the different cover cropping systems. Termination method had an effect on weed biomass with roller crimped plots showing greater weed biomass after termination. Cover crops differed in their ability to suppress weeds, however, rye showed suppression levels of approximately 90 percent which were similar to or greater than levels achieved by all herbicide systems. Combining rye with the spring residual herbicide also effectively suppressed horseweed. Across both years, herbicide plots showed greater levels of horseweed suppression than attained by any of the cover crop systems. Soybean yields were also greatest in herbicide plots. Data indicates that combining both cover crop and herbicide systems may provide growers with an alternative method to suppress horseweed.

DUPONT AFFORIA HERBICIDE: NEW BURNDOWN OPTION FOR VARIABLE PH SOILS. Keith A. Diedrick*[1], Helen A. Flanigan[2], Keith D. Johnson[3], Bruce W. Carlson[4]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont, Greenwood, IN, [3]DuPont Crop Protection, Grand Forks, ND, [4]DuPont Crop Protection, Lindstrom, MN, MN (19)

Soybean growers in the upper Midwest are adopting more comprehensive preemergent and postemergent weed control strategies in glyphosate-tolerant soybeans to combat resistance and protect crop quality. The high pH soils present an added challenge, however, as they preclude the use of some residual products, such as chlorimuron, due to restrictive crop rotation intervals to important regional crops including sugar beet and potato. In 2014, DuPont Crop Protection introduced DuPont™ Afforia™ herbicide, a product with flexible placement on these soils with two modes of action providing both burndown and residual activity. Afforia™ is a dispersible granule formulation premix of tribenuron, thifensulfuron, and flumioxazin. Post-harvest or preplant applications burn down existing weeds and provide residual control of many broadleaf species and suppression of some key grass weeds. Testing in the 2014 season focused on minimum-till preplant applications in the spring. Afforia™ combined with glyphosate at labeled rates increased control of difficult-to-control weeds, such as common dandelion, kochia, and common lambsquarters when compared to treatments without residual PPO components. Crop safety at labeled rates was excellent. The addition of DuPont™ Afforia™ to the upper Midwestern soybean market provides a new option to growers to use one product with multiple modes of action and greater flexibility in crop rotation to high-value non-grain crops.

ENLIST™ AND ENLIST E3™ SOYBEAN CROP TOLERANCE. Joe Armstrong*[1], Patricia L. Prasifka[2], David C. Ruen[3], Mike M. Moechnig[4], David M. Simpson[5]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, West Fargo, ND, [3]Dow AgroSciences, Lanesboro, MN, [4]Dow AgroSciences, Toronto, SD, [5]Dow AgroSciences, Indianapolis, IN (20)

Previous research from 2008 through 2013 with Enlist™ soybean across the Mid-South and Midwest U.S. demonstrated excellent tolerance to 2,4-D when applied preemergence or postemergence. In 2014, trials were conducted to evaluate tolerance of early-maturity (Group 1) Enlist™ and Enlist E3™ soybean to applications of Enlist Duo™ herbicide with Colex-D™ Technology (a proprietary blend of 2,4-D choline and glyphosate); 2,4-D choline; glyphosate; glufosinate; and 2,4-D choline + glufosinate applied at the V6 or R2 growth stage. Early-maturity Enlist and Enlist E3 soybean demonstrated robust tolerance to 2,4-D choline at 1065 and 2130 g ae/ha, glyphosate at 1120 and 2240 g ae/ha, and Enlist Duo at 2185 g ae/ha (maximum registered application rate) and 4370 g ae/ha applied to soybean at V6 and R2 in 2014. No differences in crop tolerance between Enlist or Enlist E3 soybean were observed, and data were combined for analysis. Regardless of application rate or timing, visual injury was 2% or less for either 2,4-D choline or glyphosate alone 7 days after treatment (DAT). Enlist Duo at 2185 g ae/ha caused 3% or less injury 7 DAT for each application timing and no injury was evident 14 DAT. Enlist Duo at 4370 g ae/ha increased injury slightly to 9% 7 DAT, but injury decreased to 4% or less by 14 DAT. At 7 DAT, glufosinate applied at 542 g ae/ha at V6 or R2 resulted in injury of 6 to 9% and 16% when applied at V6 or R2 at 1084 g ae/ha. However, by 14 DAT, injury from glufosinate at 542 g ae/ha decreased to 3% or less and 9% or less for 1084 g ae/ha. The addition of 2,4-D choline to glufosinate did not increase crop injury compared to glufosinate applied alone. By 14 DAT, injury observed with 2,4-D choline + glufosinate decreased to 2% for 542 + 1065 g ae/ha and 9% for 1084 + 2130 g ae/ha. Early-maturity Enlist and Enlist E3 soybean demonstrated tolerance to 2,4-D choline, glyphosate, glufosinate, and 2,4-D choline + glufosinate applied at the V6 and R2 growth stage.

ENLIST E3™ SOYBEAN WEED CONTROL SYSTEMS IN MIDWEST. Jeff M. Ellis*[1], David C. Ruen[2], Mike M. Moechnig[3], Eric F. Scherder[4], Kristin Rosenbaum[5], Laura A. Campbell[6], Fikru Haile[7], Leah L. Granke[8]; [1]Dow AgroSciences, Smithville, MO, [2]Dow AgroSciences, Lanesboro, MN, [3]Dow AgroSciences, Toronto, SD, [4]Dow AgroSciences, Huxley, IA, [5]Field Scientist, Crete, NE, [6]Dow AgroSciences, Carbondale, IL, [7]Dow AgroSciences, Carmel, IN, [8]Dow AgroSciences, Columbus, OH (21)

The Enlist™ Weed Control system is being developed in multiple crops and includes Enlist™ soybean and Enlist E3™ soybean. Enlist is a weed control system composed of new herbicide-tolerant traits and a new herbicide solution, Enlist Duo™ herbicide. Enlist soybean when stacked with glyphosate-tolerant traits, such as Roundup Ready 2 Yield, and Enlist E3 soybean will provide tolerance to glyphosate, glufosinate and 2,4-D. Integrating multiple modes of action herbicides into a preemergence followed by postemergence weed control program provides consistent, highly effective control and helps prevent the onset of herbicide resistant weeds. Studies were conducted in 2013 (21 trials) and 2014 (12 trials) in the U.S. to evaluate the weed control delivered by a systems approach composed of preemergence (PRE) followed by postemergence (POST) herbicide applications in Enlist E3 soybeans. PRE foundation treatments consisted of cloransulam + sulfentrazone, flumioxazin + cloransulam, flumioxazin + chlorimuron ethyl or S-metolachlor + fomesafen herbicide products. Postemergence treatments of Enlist Duo (2,4-D choline + glyphosate DMA) at 1640 and 2185 g ae/ha, glufosinate at 542 g ae/ha, 2,4-D choline + glufosinate at 800 + 542 and 1065 + 542 g ae/ha, and -glyphosate at 1120 g ae/ha were applied approximately 30 days after planting. PRE applications of cloransulam + sulfentrazone or flumioxazin + cloransulam followed by Enlist Duo at 1640 or 2185 g ae/ha or 2,4-D choline + glufosinate at 800 + 542 or 1065 + 542 g ae/ha provided greater than 95% control of CHEAL, IPOSS, and ABUTH and glyphosate resistant AMATA, AMAPA, AMBEL, and AMBTR at 28 days after application.

TOLERANCE OF BANANA PEPPER (*CAPSICUM ANNUUM*) TO *S*-METOLACHLOR AND CLOMAZONE. Mohsen Mohseni Moghadam, Douglas Doohan, Andrea S. Leiva Soto*; The Ohio State University - Ohio Agricultural Research and Development Center, Wooster, OH (22)

Weed management in banana pepper (*Capsicum annuum*) continues to be a challenge for vegetable growers in Ohio as well as elsewhere. Clomazone is of particular interest to banana pepper producers because it has been registered for use in all other pepper varieties. Field experiments were conducted at the North Central Agricultural Research Station in Fremont, OH in 2006 and 2007 to evaluate the tolerance of banana pepper to *s*-metolachlor and clomazone and the efficacy of these herbicides on giant and green foxtail, common lambsquarters and common purslane. The crop was machine-transplanted in June of each year, with a 0.6 m spacing between rows. Plots were 3.1 m wide and 7.6 m long. The experimental design was a randomized complete block with 4 replications. Herbicide treatments were applied using a CO_2 pressurized backpack sprayer with 8002VS nozzle tips set at 276 kPa delivering 234 L ha^{-1}. Pre-transplant (PRETP) treatments were applied one day before transplanting on June 8, 2006, and May 29, 2007. Treatments included two *s*-metolachlor rates (534 and 1060 g ai ha^{-1}), two clomazone rates (560 and 1120 g ae ha^{-1}), and four different tank mixes of *s*-metolachlor plus clomazone (534 g ai ha^{-1} + 560 g ae ha^{-1}, 1060 g ai ha^{-1} + 560 g ae ha^{-1}, 534 g ai ha^{-1} + 1120 g ae ha^{-1}, and 1060 g ai ha^{-1} + 1120 g ae ha^{-1}). Crop injury and weed control were assessed visually using the 0-100 linear scale in which 0 indicated no crop injury/ no weed control, and 100 indicated death of crop/complete weed control. Necrosis, stunting, curly leaves, and chlorosis symptoms were evaluated. The crop was harvested two times between July and September based on the visual maturity of the control plants and total yield per plot was determined. Data were collected at 1, 2, 3, 4, 7, 10 and 14 weeks after treatment. None of the treatments caused crop injury either year. In general *s*-metolachlor provided less weed control. PRETP application of the herbicides did not reduce yield of banana pepper. These results indicate that banana pepper tolerates *s*-metolachlor and clomazone rates up to 1060 g ai ha^{-1} and 1120 g ae ha^{-1}, respectively. Rates tested provide weed control that growers would find acceptable. Registration of clomazone herbicide would provide banana pepper growers with a more effective means of controlling weeds than currently available and reduce grower dependence on cultivation and hand labor.

RELATING DICAMBA INJURY AND RESIDUE TO YIELD REDUCTION IN DRY BEAN. Theresa A. Reinhardt*, Rich Zollinger; North Dakota State University, Fargo, ND (23)

Dicamba has the potential for higher use rates on more acres but is still detrimental to dry bean. Susceptibility of soybean to dicamba has been quantified, but dry bean threshold for dicamba drift or tank contamination is uncertain. The purpose of this study is to relate visual injury and yield loss to mg kg^{-1} herbicide concentration in leaf tissue. First year field research has identified clear differences at 0.175, 1.75, and 17.5 g ai ha^{-1} of dicamba alone and in combination with glyphosate at 0.437, 4.37, 43.7 g ai ha^{-1}, respectively. The chosen rates of dicamba are meant to represent 0.06%, 0.6%, and 6% of a 280 g ai ha^{-1} use rate in corn, a simulation of dicamba that could be misapplied by improperly cleaning the spray tank or drift from another field. Treatments were applied to the center 2 meters of 3 by 12 meter plots using a CO_2 backpack sprayer fitted with 11002 Turbo TeeJet nozzles. The results of this study indicate that dicamba drift or tank contamination could result in yield loss at rates as low as 6% of the field use rate.

COVER CROP SPECIES RESPONSE TO SIMULATED HALF-LIFE DOSES OF SOYBEAN AND CORN HERBICIDES. Brittany Parker*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (24)

The use of cover crops has become more popular due to the many benefits they can provide such as suppressing weeds, recycling nutrients, and increasing soil quality. For maximum biomass in cover crops should be sown as early as possible into the standing crop so the cover crop can grow as the cash crop senesces. Herbicide half-life may be used to estimate various residue levels that might be expected in the soil at cover crop seeding. The objective of this study was to evaluate the response of ten common cover crop species to 12 selected corn and soybean herbicides that were evaluated to be 1) of widespread use and/or 2) likely to result in carryover of injurious herbicide concentrations. Red winter wheat (53 kg ha^{-1}), cereal rye (65 kg ha^{-1}), winter rapeseed (3 kg ha^{-1}), red clover (7 kg ha^{-1}), Austrian winter pea (58 kg ha^{-1}), hairy vetch (9.7 kg ha^{-1}), radish (6 kg ha^{-1}), crimson clover (2.6 kg ha^{-1}), annual ryegrass (1.2 kg ha^{-1}), and turnip (1.3 kg ha^{-1}) were planted on June 6, 2014 in 30 inch rows. The herbicides were applied on June 7, 2014 at four doses (labeled rate, 50%, 25%, and 12.5% of the labeled rate) include: 2,4-D amine (1120, 280, 70, 17.5), atrazine (1120, 560, 280, 140), dicamba (1120, 280, 70, 17.5), isoxaflutole (48, 24, 12, 6), mesotrione (210, 105, 53, 26), chlorimuron-ethyl (17.5, 8.8, 4.4, 2.2), cloransulam methyl (35.3, 17.7, 8.8, 4.4), flumioxazin (107, 53.5, 26.8, 13.4), fomesafen (329, 165, 82, 41), pyroxasulfone (240, 120, 60, 30), sulfentrazone (420, 210, 105, and 53), and sulfentrazone + chlorimuron-ethyl (420+52.5, 210+26, 105+13, 53+6). Herbicides were activated immediately following application by 3.7 cm of rain. Visual evaluations of injury on a scale of 0 (no injury) to 100 (plant death) were made 5 weeks after planting. The ratings reported below indicate crop response to herbicides at doses that would be expected approximately 3-4 months after herbicide application. Brassicacea species (turnip, radish, and rapeseed) were very sensitive to the ALS- (chlorimuron, cloransulam) and PPO-inhibiting (flumioxazin, fomesafen, sulfentrazone) herbicides evaluated. Red clover was the most sensitive of the legume species, and was the species most injured by the HPPD-inhibitors (mesotrione and isoxaflutole). The only species severely injured by pyroxasulfone was annual ryegrass. Neither 2,4-D or dicamba caused significant injury at the lowest doses evaluated. The only active ingredient mixture tested (sulfentrazone + chlorimuron) was the most injurious product across the species evaluated. Because herbicide degradation rate is strongly influenced by environmental conditions, using a dose response analysis similar to that conducted in this study may improve the predictability of cover crop response as environmental conditions vary.

SUMMER ANNUAL WEED CONTROL AS AFFECTED BY FALL, PREPLANT AND PRE TIMING OF SOYBEAN RESIDUAL HERBICIDES. Kyle R. Russell*[1], Mark L. Bernards[1], Bryan Young[2], Aaron G. Hager[3]; [1]Western Illinois University, Macomb, IL, [2]Purdue University, W. Lafayette, IN, [3]University of Illinois, Urbana, IL (25)

Common waterhemp has become a serious problem for many farmers. In a no-till system, farmers rely primarily on herbicides to manage weeds. A common recommendation for minimizing the influence of glyphosate-resistant weeds has been to include preplant or preemergence residual herbicides. An ideal scenario for no-till farmers would be to combine winter annual and summer annual weed control using an effective residual herbicide applied once several weeks in advance of planting. In this research we compare two residual herbicide mixtures in regards to their rate, timing of application, and use of split applications on management of common waterhemp. Burndown and residual herbicides were applied the fall before planting (Fall), 4 weeks before planting (EPP) or at planting (PRE). The residual herbicides were flumioxazin plus chorimuron-ethyl (F+C) and sulfentrazone plus chlorimuron-ethyl (S+C). Single application rates were high (F+C – 105+36 g ha-1; S+C – 418+52 g ha-1) or low (F+C – 79+27 g ha-1; S+C – 219+27 g ha-1). Split rates were F+C (40+14 g ha-1) or S+C(110+14 g ha-1) applied either Fall+EPP, Fall+PRE, or EPP+PRE. The research was conducted on university-associated farms associated in Urbana, Murphysboro, and Macomb, IL in 2012, 2013 and 2014. Data from eight site years were included in the analysis. Time of application was the most important factor in waterhemp control at planting and four weeks after planting (4WAP). Weed control efficacy declined as time between application and evaluation increased, e.g., waterhemp control where residual herbicides were applied in the fall was 75% at planting and 50% 4WAP. There was no difference in waterhemp control between the high and low herbicide rates at planting or 4WAP. The two residual herbicide mixtures provided the same level of weed control. Waterhemp control 28 DAP with the split application treatments was equal to the low rate single application treatments, but was less than the high rate single application treatments. Yields where single applications of residual herbicides were least for the Fall timing (3288 kg ha-1), greatest for the EPP timing (3604 kg ha-1), or intermediate for the PRE timing (3449 kg ha-1), p=0.05.

SOYBEAN YIELD RESPONSE TO COVER CROP AND WINTER ANNUAL WEED REMOVAL TIME AND SOYBEAN PLANTING DATE. Aaron P. Prins*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (26)

Many no-till acres in the Midwest host large populations of winter annual weeds. Recent observations have suggested that failure to control winter annual weeds until the time of corn (*Zea mays)* and soybean *(Glycine max)* planting can reduce potential yield by 10% or more, as compared to controlling winter annual weed species in the late fall or early spring. An increasing number of farmers are including a cover crop to improve soil structure and biology, weed control and soil fertility. Cover crops and winter annual weeds fill a similar niche and may be adapted to serve similar purposes. The objective of this study was to compare the effect of natural populations of winter annual weeds or cover crops removal time on soybean growth and yield. Rye (*Secale cereal*) was drilled on October 2, 2013 at the two study locations. Winter rapeseed (*Brassica napus*) was broadcasted concurrently with the rye. Annual weed species that were prevalent within the study included common chickweed (*Stellaria media*), annual bluegrass (*Poa annua*), shepherd's purse (*Capsella bursa-pastoris*), buttercup (*Ranunculus spp.*), henbit (*Lamium amplexicaule*) and purslane speedwell (*Veronica pergrina*). The winter rapeseed and many of the fall-emerged winter annual weeds died during the winter, but spring-emerging winter annual species provided ground cover by late April. Other weed species in the study area included waterhemp (*Amaranthus rudis*) and common lambsquarters (*Chenopodium album*). Winter annual weeds and cover crops were removed using a burndown herbicide application of glyphosate plus sulfentrazone and chlorimuron-ethyl at four times relative to the treatment planting date: Fall (October 1, 2013), 28 DBP (days before planting), 14 DBP or 0 DBP. Soybeans were planted on three different dates: early (May 8, 2013) middle (May 13, 2013) and late (June 7, 2013) using a four row John Deere 7000 planter. Rows were spaced 76 cm apart and seeded at 395,000 seeds per/ha. Soybean plots were kept weed free from the time of the initial removal until harvest. The pattern of yield response to the treatments was similar at the two study locations. Soybean yields were greater where the rye cover crop was grown than where winter annual weeds provided the groundcover. Yields were greatest for the mid-planting date, intermediate for the early planting date and least for the late planting date. The lower than expected yields for the first planting date may have been a consequence of severe sudden death syndrome (*Fusarium virguliforme*) symptoms present in the plots. For the early planting date delaying the removal of cover crop or winter annual weed cover until 14 DBP resulted in yield loss. For the mid- and late-planting date treatments there was a linear relationship and yields declined relative to the fall removal time as cover crop or winter annual removal was delayed until planting.

FULL RATES, MULTIPLE HERBICIDES, OR BOTH? CONSIDERATIONS FOR BEST MANAGEMENT PRACTICES FOR RESIDUAL CONTROL OF WATERHEMP IN SOYBEAN. Nick T. Harre*[1], Joseph L. Matthews[2], Julie M. Young[2], Mark Bernards[3], Aaron G. Hager[4], Bryan Young[5]; [1]Purdue University, West Lafayette, IL, [2]Southern Illinois University, Carbondale, IL, [3]Western Illinois University, Macomb, IL, [4]University of Illinois, Urbana, IL, [5]Purdue University, W. Lafayette, IN (27)

The use of PRE herbicide tank-mixtures has greatly increased in recent years as a management tactic to integrate multiple herbicide sites-of-action for control of problematic and herbicide-resistant weed species. In soybean, PPO-inhibiting herbicides applied PRE have been frequently utilized to manage waterhemp, one of the most prolific and troublesome weeds invading production areas. However, the frequency of soybean injury from these applications in recent years has escalated which presents an even greater concern as application rates have increased to near full-labeled rates for longer residual activity, as well as the unpredictable interaction of these herbicides with other soil residual herbicides applied in combination. Two separate field experiments were conducted at Southern Illinois University and the University of Illinois in 2011, 2012, and 2014. The first experiment examined the effect of reduced- and full-rates of the PPO-inhibitor herbicides sulfentrazone and flumioxazin in combination with five tank-mix partners on residual waterhemp control. A second experiment evaluated the influence of the same herbicide treatments at a 1X (full) and 2X field use rate on soybean injury and grain yield in a weed-free environment. Droughty conditions following planting in 2012 resulted in poor weed control and limited soybean injury from all PRE herbicide treatments. Accordingly, only results for 2011 and 2014 will be presented. The full-rate of sulfentrazone or flumioxazin alone was equally as effective as a reduced-rate of these herbicides in combination with a PRE tank-mixtures for waterhemp control 21 days after planting (DAP). By 42 DAP, control of waterhemp from full-rates of sulfentrazone or flumioxazin alone was more variable and marginally less than when an additional PRE herbicide was included; when used at reduced rates, control was greatly enhanced by the inclusion of a PRE tank-mix partner. Soybean injury from PRE herbicide tank-mixtures were greater in treatments containing flumioxazin compared with sulfentrazone and were greatest in those in which *s*-metolachlor was applied with flumioxazin and when 2X field use rates were applied. Thus, the label restrictions for flumioxazin products combined with chloroacetamide herbicides, such as *s*-metolachlor, is justified to avoid soybean injury. At 21 DAP, soybean injury was largely transient and was weakly associated with soybean grain yield ($R^2 = 0.14$), whereas, injury that persisted to 63 DAP was a more useful indicator of soybean grain yield loss ($R^2 = 0.51$). These results suggest that using a reduced-rate of sulfentrazone or flumioxazin alone provide poor and erratic residual-control of waterhemp. Applying a full-rate of these herbicides alone or by including a tank-mix partner greatly enhance and extend the control of waterhemp. Although growers may be hesitant to broadly accept the use of full-rates and multiple PRE herbicides due to increased management costs and soybean injury, grain yield losses are unlikely and this tactic may be particularly beneficial in managing areas heavily infested with herbicide-resistant waterhemp.

OPTIONS FOR CONTROLLING GLYPHOSATE-RESISTANT KOCHIA PREPLANT. Brian M. Jenks*; North Dakota State University, Minot, ND (28)

No abstract submitted

VOLUNTEER CORN COMPETES WITH SUGARBEET FOR NITROGEN. Amanda C. Harden*, Christy L. Sprague; Michigan State University, East Lansing, MI (29)

Volunteer glyphosate-resistant (GR) corn in GR sugarbeet is a common problem for Michigan sugarbeet growers. Michigan research has shown that volunteer corn populations of 1.7 plants m^{-2} significantly reduced sugarbeet yield and recoverable white sugar per hectare. Volunteer corn also needed to be controlled by the V4 growth stage to maximize sugarbeet yield and quality. To determine if competition for nitrogen may be contributing to the sugarbeet yield losses associated with volunteer corn, a greenhouse study was conducted in East Lansing, Michigan in 2014. GR sugarbeet "HM 173 RR" and GR volunteer corn (F_2) were grown in a replacement series design with four replications at proportions of 100:0, 75:25, 50:50, 25:75, and 0:100 with 8 plants pot^{-1}. Nitrogen fertilizer was applied as an aqueous solution of urea (46-0-0) at rates of 0, 67, 101, 134, and 168 kg N ha^{-1}. All pots were sub-irrigated. At the sugarbeet four-leaf stage (~5.5 WAP), sugarbeet and volunteer corn were harvested separately for biomass and nitrogen concentration measurements. Relative yield and relative nitrogen assimilation were calculated by comparing sugarbeet and volunteer corn grown in mixture with respective monocultures. The nitrogen concentration of sugarbeet grown in monoculture was 43% higher than the nitrogen concentration of volunteer corn grown in monoculture when data were combined over nitrogen rates. In each mixture, total nitrogen concentration, relative yield, and relative nitrogen assimilation was greater in sugarbeet than in volunteer corn. Sugarbeet competed more effectively for nitrogen than volunteer corn at each nitrogen rate, but was most aggressive when 168 kg N ha^{-1} was applied. These results indicate that early-season competition for nitrogen is not a primary yield-reducing factor contributing to the suppression of sugarbeet growth and development by volunteer corn.

COVER CROPS AND HERBICIDE PROGRAMS FOR MANAGEMENT OF PALMER AMARANTH (*AMARANTHUS PALMERI*) IN SOYBEAN SYSTEMS RESISTANT TO GLYPHOSATE AND GLUFOSINATE. Douglas J. Spaunhorst*, William G. Johnson; Purdue, West Lafayette, IN (30)

A field experiment evaluating annual ryegrass and cereal rye cover crops for management of Palmer amaranth was conducted at Throckmorton Purdue Agricultural Center near Lafayette, Indiana. Glufosinate and glyphosate-resistant soybean were established in an area infested with glyphosate-resistant and susceptible Palmer amaranth to determine if soybean system, cover crop type, and or herbicide treatment influence Palmer amaranth efficacy and soybean grain yield. Regardless of herbicide treatment and soybean system, a fall planted cereal rye cover crop resulted in 654 kg ha^{-1} more soybean grain yield and 16% greater control than treatments with no cover crop. In our experiment, the fall planted annual rye cover crop winter killed due to lack of winter hardiness. Treatments with an annual ryegrass cover crop resulted in similar soybean grain yield when compared to treatments with no cover crop or a cereal rye cover crop. However, control data suggests a cereal rye cover crop can provide greater control of Palmer amaranth than an annual ryegrass or no cover crop treatment in the absence of herbicides. Differences in soybean grain yield and Palmer amaranth control were not observed between soybean system and when comparing a one pass to a two pass herbicide treatment. However, soybean grain yield in all one pass and two pass systems were greater than the non-treated control. A priori orthogonal contrast between all possible combinations of cover crops suggests without herbicides glyphosate-resistant soybean planted into a cereal rye cover crop can provide 810 to 945 kg ha^{-1} more soybean grain yield than an annual ryegrass and no cover crop treatment, respectively ($P \leq 0.1$). Similarly, glufosinate-resistant soybean planted into cereal rye resulted in 1506 and 1631 kg ha^{-1} more soybean grain yield than an annual ryegrass and no cover crop treatment, respectively ($P \leq 0.05$). In only one instance soybean grain yield was 851 and 883 kg ha^{-1} greater with herbicides plus a cereal rye cover crop treatment compared to no cover crop or an annual ryegrass cover crop with herbicides, respectively. Differences in end of season Palmer amaranth control were not observed between any cover crop plus herbicide treatment. End of season Palmer amaranth control and soybean grain yield support that cereal rye can suppress Palmer amaranth more than an annual ryegrass or no cover crop treatment when no herbicides are applied after crop establishment.

INFLUENCE OF HERBICIDE PROGRAMS ON GLYPHOSATE-RESISTANT COMMON WATERHEMP CONTROL IN GLYPHOSATE TOLERANT SOYBEAN.
Debalin Sarangi*[1], Lowell D. Sandell[1], Amit J. Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (31)

Common waterhemp (*Amaranthus rudis* Sauer) is a highly competitive annual broadleaf weed that has a significant detrimental effect on crop yield. Control of glyphosate-resistant common waterhemp is a major challenge for soybean growers in midwestern United States, because very few effective postemergence (POST) soybean herbicide options are available. Field experiments were conducted in Dodge County, Nebraska in 2013 and 2014 to evaluate the efficacy of several herbicide programs for glyphosate-resistant common waterhemp control and their impact on soybean injury and yields. The results suggested that all the preemergence (PRE) herbicide treatments resulted in ≥ 83% control of glyphosate-resistant common waterhemp at 14 DAP. POST-only herbicide programs including fomesafen tank-mixed with imazethapyr, glyphosate, and acetochlor followed by lactofen plus glyphosate resulted in 82% common waterhemp control, and reduced density to 30 common waterhemp plants m^{-2} at 42 DAP. Poor control (23 %) of common waterhemp was observed at soybean harvest with sequential applications of glyphosate, which resulted in lower soybean yield (≤ 1,289 kg ha^{-1}). PRE herbicide applications of saflufenacil plus imazethapyr plus dimethenamid-P, sulfentrazone plus chloransulam, *S*-metolachlor plus fomesafen, or *S*-metolachlor plus metribuzin, followed by fomesafen or acifluorfen tank-mixed with glyphosate provided ≥ 91% control of common waterhemp throughout the growing season; and resulted in higher soybean yield (≥ 2,201 kg ha^{-1}). The results of this study indicate that glyphosate-resistant common waterhemp can be effectively controlled with several PRE residual herbicides in glyphosate-tolerant soybean, when they were followed by POST treatments of PPO-inhibiting herbicides such as fomesafen or acifluorfen; however, over reliance on PPO-inhibitors may result in evolution of multiple herbicide-resistant common waterhemp biotypes.

INFLUENCE OF LATE SEASON HERBICIDE APPLICATION ON SEED PRODUCTION AND FECUNDITY OF GLYPHOSATE-RESISTANT GIANT RAGWEED (*AMBROSIA TRIFIDA*).
Simranpreet Kaur*[1], Roger Elmore[2], Zac J. Reicher[3], Amit J. Jhala[4]; [1]University of Nebraska Lincoln, Lincoln, NE, [2]University of Nebraska lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska-Lincoln, USA, Lincoln, NE (32)

Glyphosate-resistant giant ragweed is a competitive weed of agronomic crops predominantly distributed in Mid-west and eastern United States. Late-season herbicide applications provide an advantage to control weeds that have escaped weed control practices earlier in the season. Field experiments were conducted in David City, NE in 2013 and 2014. Glyphosate, glufosinate, 2,4-D and dicamba were first applied to all the plots when glyphosate-resistant giant ragweed plants were nearly 50 cm tall and the second application of herbicides was made in selected treatments 40 to 45 days after first application. Similar experiments were conducted in greenhouse. Results suggested that 2,4-D and dicamba provided 99% control of glyphosate-resistant giant ragweed in greenhouse at 15 days after treatment (DAT) and maximum seed production (28 seeds $plant^{-1}$) was observed in treatments including glyphosate. Under field conditions, 2,4-D and dicamba resulted 55-67% control, that was comparable to control achieved by split application of glufosinate at 7 days after first treatment (DAFT) that increased upto 75% at 28 DAFT. Plots that were applied with herbicides only once resulted in lower control (< 62%) of giant ragweed due to regrowth or late season emergence. Although comparable to 2,4-D and dicamba, split application of glufosinate provided maximum control upto 83 and 91% at 7 and 28 days after second treatment (DAST), respectively. Similiarly, 89-94% control of inflorescence was achieved at only in treatments that were applied twice at 28 DAST. 2,4-D and dicamba applied once provided 65 and 82% control of inflorescence, respectively; however one time application of glufosinate did not affect seed production of glyphosate-resistant giant ragweed due to regrowth.

INFLUENCE OF PREHARVEST HERBICIDE APPLICATIONS ON COLOR RETENTION OF CANNED BLACK BEANS.
Amanda M. Goffnett*[1], Christy L. Sprague[1], Karen A. Cichy[2]; [1]Michigan State University, East Lansing, MI, [2]USDA-ARS, East Lansing, MI (33)

Growers commonly use preharvest herbicides to accelerate black bean maturation and provide uniformity. Herbicide choice, application timing, and black bean variety may influence color retention of the canned black bean product. Field trials were conducted at the Saginaw Valley Research and Extension Center near Richville, Michigan, in 2013 to evaluate the effects of preharvest treatments on the color retention of black beans after canning. Type II black bean varieties 'Zorro', 'Eclipse', and 'Zenith' were planted on two dates, June 13 and June 26 (at the beginning and end of the ideal planting time for the region). Three preharvest treatments were tested: 1) paraquat (0.56 kg ha^{-1}) + non-ionic surfactant (0.25% v/v); 2) glyphosate (0.84 kg a.e. ha^{-1}) + ammonium sulfate (2% w/w); and 3) saflufenacil (0.05 kg ha^{-1}) + methylated seed oil (1% v/v) + ammonium sulfate (2% w/w). An untreated control was established for each variety. Preharvest treatments were applied at two different timings for each planting date; at 50% pod yellowing (early) and 80% pod yellowing (standard). Beans were direct harvested, adjusted to 18% moisture, and canned using a small scale protocol. Canned samples were assessed for color by 22 trained evaluators, using a scale from 1 (poor or unacceptable) to 5 (excellent). Black bean color was also evaluated by measuring the luminosity (L) value with a colorimeter, ranging from 0 (black) to 100 (white). Differences among black bean varieties were observed. 'Zenith' retained the darkest color, while 'Eclipse' revealed the lightest color regardless of planting date or application timing. Luminosity measurements indicate lighter bean color when paraquat or glyphosate were applied early in the first planting when compared with the control plot. In the second planting, only glyphosate applied at the early timing resulted in lighter color measurements. Effects of herbicides applied at the standard timing were not different from those in the untreated plots for both planting dates. A variety by herbicide interaction was observed for visual color assessments by the evaluator panel at the early application timing for both planting dates. The color of black beans was not as acceptable when paraquat or glyphosate were applied early to 'Zenith' and 'Eclipse', or when glyphosate was applied to 'Zorro' for the first planting. In the second planting, early applications of glyphosate on 'Zorro' and saflufenacil or glyphosate on 'Zenith' resulted in lighter bean color. Overall, the color of canned black bean was influenced by herbicide application timing and black bean variety. This research will be repeated to further evaluate these influences.

EDAMAME TOLERANCE TO BENTAZON, FOMESAFEN, IMAZAMOX, LINURON, AND SULFENTRAZONE. James L. Moody*[1], Martin M. Williams II[2], Randall L. Nelson[2]; [1]University of Illinois, Urbana, IL, [2]USDA-ARS, Urbana, IL (34)

Poor weed control, resulting from limited herbicide availability and undeveloped integrated weed management systems, is a major hurdle to production of edamame in the U.S. Edamame, the same species as grain-type soybean, has few registered herbicides due to unknown crop tolerance. Tolerance of as many as 128 edamame entries to a 2X registered rate of bentazon, fomesafen, imazamox, linuron, and sulfentrazone was quantified within four weeks after treatment in field trials. Several grain-type soybean entries were included for comparison, including entries with known herbicide tolerance or sensitivity. Injury and seedling growth reduction to all edamame entries was comparable to all grain-type entries for fomesafen, linuron, and sulfentrazone; and less than all grain-type entries for bentazon and imazamox. Responses of ten of the more widely used edamame entries were comparable to grain-type entries with known herbicide tolerance. Bentazon, fomesafen, imazamox, linuron, and sulfentrazone pose no greater risk of adverse crop response to edamame germplasm than the grain-type soybeans to which they have been applied for years. Since initiation of this research, fomesafen, imazamox, and linuron are now registered for use on the crop in the U.S. Development of integrated weed management systems for edamame would benefit from additional herbicide registrations.

TECHNICAL ATTRIBUTES OF FIERCE XLT. Eric J. Ott*[1], John A. Pawlak[2], Dawn E. Refsell[3], Lowell Sandell[4], Trevor Dale[5]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA Corporation, Lansing, MI, [3]Valent USA Corporation, Lathrop, MO, [4]Valent USA Corporation, Lincoln, NE, [5]Valent USA Corporation, Plymouth, MN (35)

Fierce XLT is a new herbicide recently registered for broad spectrum preemergence weed control in soybean. Fierce XLT is a premix of herbicides from three different modes of action (WSSA groups 2, 14, and 15) comprising of flumioxazin, pyroxasulfone, and chlorimuron-ethyl. The product is formulated as a 62.41% WDG. The chemical and physical properties of the herbicides that comprise Fierce XLT will allow for broader spectrum, longer lasting residual preemergence control over other herbicides. Efficacy data has been collected on over 49 large- and small-seeded broadleaf weeds and 19 grass weeds. The water solubility of flumioxazin at 25°C is 1.89 mg/L, pyroxasulfone 3.49 mg/L at 20°C, chlorimuron-ethyl 4.1 mg/L at pH 4.2, and Koc values of flumioxazin 201-620, pyroxasulfone 119-226, and chlorimuron-ethyl 110. These characteristics of Fierce XLT aid in providing consistency in performance over a wide range of soil and moisture conditions. Field use rates for Fierce XLT will be 4 to 5.25 oz/A of formulated product. This is equivalent to active ingredient rates of flumioxazin 69.5 to 90.8 g ai/ha, pyroxasulfone 87.4 to 114.3 g ai/ha, and chlorimuron-ethyl 19.8 to 24.6 g ai/ha.

INVESTIGATION OF FLURIDONE AS A PREEMERGENT HERBICIDE IN SOYBEAN. Austin H. Straatmann*[1], Mandy D. Bish[2], Alex R. Long[2], Meghan E. Biggs[2], Kevin W. Bradley[2]; [1]University of Missouri, Villa Ridge, MO, [2]University of Missouri, Columbia, MO (36)

Fluridone is a phytoene desaturase-inhibiting herbicide that has been used in aquatic situations since the early 1990's to control weeds such as eurasian watermilfoil and hydrilla. In 2012, the U.S. Department of Agriculture granted a Section 18 emergency exemption label for the use of fluridone in cotton for the control of herbicide-resistant Palmer amaranth in several southern states. A field study was conducted in Missouri to determine the effectiveness of fluridone as a preemergent (PRE) herbicide for the control of herbicide-resistant waterhemp and other common summer annual weed species, and to evaluate soybean phytotoxicity and yield in response to fluridone treatment. Fluridone was applied PRE at rates of 0.17, 0.22, 0.34, or 0.67 kg/ha either alone or in combination with sulfentrazone plus chlorimuron, *S*-metolachlor, fomesafen plus *S*-metolachlor, and pyroxasulfone plus flumioxazin. For comparison, these latter herbicides were applied without fluridone, and a commercial premix of fomesafen plus fluridone was also evaluated. Visual ratings of weed control and soybean injury revealed that the 0.67 kg/ha fluridone rate applied alone provided the highest levels of weed control among fluridone treatments and similar levels as the comparison treatments, but visual soybean injury and yield loss were too severe in response to this rate of fluridone. Visual soybean injury was less than 10% and comparable to commercial standards with the 0.17, 0.22, and 0.34 kg/ha rates of fluridone, but waterhemp control was less than 62% with any of these rates. The addition of any other PRE herbicide to the 0.17 or 0.34 kg/ha rate of fluridone resulted in greater than 93% control of waterhemp, and generally provided similar or higher levels of summer annual weed control as fluridone alone. The commercial premix of fomesafen plus fluridone at 0.14 plus 0.22 kg/ha to 0.21 plus 0.34 kg/ha also provided good control of waterhemp and other common summer annual weeds without substantial soybean injury. These results indicate that fluridone rates of 0.67 kg/ha or higher can result in unacceptable soybean injury and yield loss, and that fluridone would most likely not fit as a stand-alone PRE herbicide in soybean. In previous work, Australian researchers have found that 50 µM fluridone increased the germination of seed of wild radish (*Raphanus raphanistrum* L.), wild oat (*Avena fatua* L.), rigid ryegrass (*Lolium rigidum* Gaudin), and several other weed species by 10 to 40% compared to seeds not subjected to fluridone treatment. Similar experiments were conducted to investigate the ability of fluridone to stimulate waterhemp seed germination. Waterhemp seeds were plated on 1% water agar plates containing either 50 µM, 100 µM, 150 µM, 200 µM, or 500 µM fluridone; 300 µM abscisic acid (ABA), which inhibits seed germination; or 50 µM giberellic acid (GA), which promotes seed germination. Experiments were conducted in triplicate. One week following plating, seed germination was analyzed. Fifty seeds per treatment were examined using a dissecting microscope and counted as germinated if the radical had emerged. Germination rates of waterhemp seed grown on 50 µM, 100 µM, 150 µM, and 200 µM fluridone were comparable to the control (74% germination), but the ABA and 500 µM fluridone treatments resulted in 10.4 and 17.3% germination, respectively. Tetrazolium viability staining of the seed from the ABA and 500 µM fluridone plates revealed that approximately 50% of the seed on each plate were still viable. Based on this initial assay, it does not appear that fluridone is able to increase the germination of waterhemp seed. More work is needed to determine whether fluridone has an effect on the germination of other summer annual weeds commonly encountered in Missouri corn and soybean production systems.

PERFORMANCE OF A NEW CLETHODIM FORMULATION. Laura Hennemann*, Gregory Dahl, Joe Gednalske, Eric Spandl, Lillian Magidow; Winfield, River Falls, WI (37)

Winfield has introduced a new clethodim formulation named Section® Three. The Section® Three formulation contains clethodim at 360 g ai/L. This product allows applicators to cover one-third more hectares with the same volume of product compared to current clethodim formulations with 240 g ai/L or less. Section® Three is labeled on the same crops and has the same tank mix compatibilities as currently marketed clethodim herbicides. Target weeds include volunteer corn, volunteer sorghum, annual grasses, and perennial grasses. Use rates for Section® Three are from 194 ml/ha to 779 ml/ha. The volume of product applied is 66% of the volume of 240 g ai/L clethodim formulations. Multiple trials were conducted in 2013 and 2014. Section® Three was tested using the code number AGH 13009. Trials compared Section® Three current 240 g ai/L clethodim formulations at various use rates, with various adjuvant packages, and multiple tank mix partners. Tank mix partners included various herbicides, insecticides, fungicides, and foliar micronutrients. Control of corn, wheat, oats, foxtails and other grasses with Section® Three was at least equal to the 240 g ai/L clethodim formulation when applied at the same ai/ha rate. Section® Three provided excellent weed control and tank-mix compatibility when tank mixed with glyphosate, chlorimuron-ethyl, cloransulam-methyl, fomesafen, acifluorfen, certain foliar micronutrients, prothioconazole + trifloxystrobin, pyraclostrobin, fluxaproxad + pyraclostrobin, bifenthrin, permethrin, and deltamethrin. There was no antagonism or incompatibility observed with the tank mixtures. Section® Three was applied with different adjuvant systems. Oil type adjuvants such as High Surfactant Oil Concentrates (HSOC) provided the greatest weed control. MSO based HSOC adjuvants and petroleum based HSOC provided the greatest weed control of the adjuvants tested.

MONITORING THE CHANGES IN GLYPHOSATE-RESISTANT WEED POPULATIONS IN CONTINUOUS DICAMBA-RESISTANT SOYBEAN FOR FOUR YEARS. Isaiah L. Akers*, Meghan E. Biggs, Alex R. Long, Mandy D. Bish, Kevin W. Bradley; University of Missouri, Columbia, MO (38)

A 4-year field study was conducted to determine the effects of 9 different herbicide programs on glyphosate-resistant and -susceptible weed populations in continuous dicamba-resistant soybean. Each year prior to planting and pre-plant herbicide application, 10 soil cores measuring 5 cm wide by 5 to 7 cm in depth were randomly collected from each plot. Soil from the cores was spread evenly across greenhouse flats, and emerged weed seedlings were counted before and after treatment with a discriminating dose of 1.56 kg glyphosate ae ha^{-1} to determine the proportion of seedlings with glyphosate resistance. The greenhouse screening revealed that glyphosate-resistant waterhemp was the predominant species present in all plots from 2011 to 2014. By 2014, only the following herbicide programs resulted in similar proportions of glyphosate-resistant waterhemp as in 2011: a 4-year continuous herbicide program consisting of a PRE herbicide followed by glyphosate; an alternating program of PRE herbicide followed by glyphosate in years 1 and 3 and PRE herbicide followed by POST non-glyphosate herbicide in years 2 and 4; an alternating program consisting of glyphosate plus dicamba in years 1 and 3 and a PRE herbicide followed by non-glyphosate POST herbicide in years 2 and 4; a 4-year continuous non-glyphosate PRE followed by POST herbicide program; and a 4-year continuous program using glyphosate plus dicamba PRE followed by glyphosate and dicamba and acetochlor POST. All other herbicide programs resulted in significantly higher proportions of glyphosate-resistant waterhemp in 2014 compared to 2011. In the field, weed counts were conducted in each plot at the time of the last

POST herbicide application and just prior to soybean harvest. In 2013, the final weed count data at harvest was lost due to human error. Field plots that received a continuous glyphosate-only herbicide program over the 4-year time period contained the most weeds at harvest in both 2012 and 2014 compared to all other herbicide programs. Glyphosate-resistant giant ragweed began increasing in plots that received glyphosate only in 2012, and by the 2014 harvest, giant ragweed was present at 92 plants per m^2 (twice as many as in 2012) while the waterhemp population had decreased to 2 plants per m^2. By 2014, total weed densities at harvest were greatest in those plots that received either the glyphosate-only or the continuous PRE herbicide followed by glyphosate POST herbicide programs. All other herbicide programs resulted in similar weed densities at harvest by 2014. The results from this 4-year study suggest that herbicide programs that include dicamba or a non-glyphosate PRE followed by POST herbicide treatment were most effective at reducing the density and proportion of glyphosate resistance in weeds such as waterhemp and giant ragweed.

WINTER ANNUAL WEEDS AND CEREAL RYE SUPPRESSION OF WATERHEMP IN SOYBEAN. Kristina Simmons*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (39)

One potential benefit of cover crops is the potential to suppress summer annual weeds such as waterhemp. Winter annual weeds occupy a similar niche to winter annual cover crops in a corn-soybean rotation and may also provide suppression of summer annual weeds. Delaying cover crop or winter annual weed control until the time of soybean planting maximizes winter cover biomass but may have negative effects on soybean yield. Early-planted soybean maximizes soybean yield potential, but limits the amount of cover crop biomass that can be grown and may limit the weed suppression benefit of the cover crop. The objective of this research was to compare the effects of winter annual weeds or a rye cover crop on waterhemp suppression as affected by winter cover removal time and soybean planting date. Two experiments (one rye cover, the other winter annual weed cover) were laid out side-by-side and were established at two locations (AFL and Kerr farms). Rye (*Secale cereal*) was drilled on October 2, 2013 at the two study locations. Winter rapeseed (*Brassica napus*) was broadcasted concurrently with the rye, but did not survive the severe cold of winter. Winter annual weeds and cover crops were removed using a burndown herbicide application of glyphosate at four times relative to the treatment planting date: Fall (Nov 15, 2013), 28 DBP (days before planting), 14 DBP or 0 DBP. Soybeans were planted on three different dates: early (May 8, 2013), middle (May 13, 2013) and late (June 7, 2013). Winter cover biomass was measured at the time of removal. Weed counts were made in two 0.1 m2 quadrats per plot at planting, 5 WAP (weeks after planting), and 8 WAP. Biomass samples were collected from the quadrats at 5 and 8 WAP, dried and weighed. Biomass at the time of winter cover removal increased as removal time was delayed until planting. The greatest amount of biomass was accumulated in the rye cover crop for the late planting date. Waterhemp counts at the time of planting following winter annual weed cover was greatest at the 28 DBP removal time (2.4 plants/0.1m2). Waterhemp counts following the rye cover were not consistent between locations. At AFL counts were greatest for the Fall removal time (5.1 plants/0.1m2) and declined until 0 DBP (0.1 plants/0.1m2), but there were no differences in counts between the removal time treatments at Kerr (average of 0.8 plants/0.1m2). Waterhemp counts at 5 WAP and 8 WAP were not affected by planting date or removal time following winter weeds or a rye cover crop.

2,4-D UPTAKE AND TRANSLOCATION IN ENLIST™ CROPS. Joshua J. Skelton*[1], David M. Simpson[2], Mark A. Peterson[3], Dean E. Riechers[4]; [1]University of Illinois, Champaign, IL, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Indianapolis, IL, [4]University of Illinois, Urbana, IL (40)

The Enlist™ Weed Control System provides a new, novel means of conferring 2,4-D tolerance to several crops including soybean and corn. Enlist Duo™ herbicide is a premix of 2,4-D choline and glyphosate for use in Enlist™ crops. Insertion of the *aad-12* gene in soybeans and *aad-1* gene into corn, which encode bacterial aryloxyalkanoate dioxygenase (AAD) enzymes, provides rapid metabolism of 2,4-D to dichlorophenol. Much is known about the AAD enzymes and its catalyzed reaction, less has been reported on 2,4-D uptake and translocation in Enlist crops and non-transformed (NT) crop varieties. To gain insight into uptake and translocation of 2,4-D in Enlist soybean and corn relative to NT varieties, a whole-plant growth chamber assay utilizing [URL-^{14}C]-2,4-D was conducted in 2013 and 2014. The whole-plant assay provided information on 2,4-D uptake and translocation during a time course of 24 hours. There was no difference in uptake between Enlist soybean and NT soybean; therefore, data were combined across soybean types. In soybeans, 2,4-D uptake was significantly greater when the adjuvant from Enlist Duo was included compared to treatments without the adjuvant. At 24 hours after application (HAA), the amount of ^{14}C-material remaining in the treated soybean leaf from each study was 81.8% and 93.0% in NT soybean compared to 98.1% and 98.3% in the Enlist soybean. 2,4-D uptake in corn with Enlist Duo at 24 HAA was 56.7% compared to 95% in soybean. There was no difference between Enlist and NT corn in the ^{14}C-material absorption into or translocation out of the treated corn leaf. Enlist Duo provides the greatest amount of 2,4-D uptake in soybeans and least amount of uptake in corn. Further research into the difference in uptake between soybean and corn with Enlist Duo may help clarify why injury occurs less frequently in Enlist corn than in Enlist soybean. ™ Enlist and Enlist Duo are trademarks of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Enlist Duo herbicide is not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. Always read and follow label directions.

EFFECT OF FOLIAR FERTILIZERS, WATER PH, AND PLANT HEIGHT ON HORSEWEED CONTROL WITH MESOTRIONE. Pratap Devkota*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (41)

A field study was conducted at Meigs Research Farm, Purdue University, IN to evaluate the effect of foliar fertilizers, carrier water pH, and plant height on mesotrione efficacy for horseweed control. Carrier water treatments consisted of combinations of zinc or manganese fertilizers (at 2.5 and 3.75 L ha^{-1}, respectively) with water pH set at 4, 6.5, or 9. Mesotrione was applied at 105 gm ai/ha to 7.5-, 12.5-, or 17.5-cm tall horseweed. Zinc and manganese fertilizers did not reduce the efficacy of mesotrione for percent control, height reduction, and dry biomass on horseweed. Mesotrione applied with carrier water at different pH levels showed variable response on percent control and height reduction on horseweed. Mesotrione applied with water at pH 6.5 provided higher control compared to pH 9 at 2 and 4 wk after treatment (WAT), and resulted in shortest horseweed plants at the end-of the season. Similarly, mesotrione efficacy differed with respect to the horseweed height for percent control, plant height reduction, and biomass. Mesotrione sprayed on 7.5, 12.5, and 17.5 cm tall horseweed provided 91, 72, and 61% control, respectively, at 4 WAT which corresponded to the final plant height of 4.8, 19, and 33 cm, respectively. The dry biomass were 0.19, 2.05, and 5.6 gm $plant^{-1}$ with mesotrione application on 7.5, 12.5, and 17.5 cm tall horseweed. In conclusion, mesotrione applied with carrier water pH at 6.5 and when plants are up to 7.5 cm tall results in horseweed control ≥91%.

THE EPSPS PRO106SER SUBSTITUTION SOLELY ACCOUNTS FOR GLYPHOSATE RESISTANCE IN A GOOSEGRASS POPULATION FROM TENNESSEE. Janel L. Huffman*[1], Chance W. Riggins[2], Lawrence E. Steckel[3], Patrick J. Tranel[2]; [1]University of Illinois, Champaign/Urbana, IL, [2]University of Illinois, Urbana, IL, [3]University of Tennessee, Jackson, TN (42)

Goosegrass (*Eleusine indica*) is a problematic summer annual weed that has a strong tendency to evolve resistance to herbicides. Previous studies have documented the occurrence of glyphosate-resistant (GR) goosegrass and, in at least some cases, resistance is due to an altered target site. Past research with a Tennessee GR goosegrass population indicated that resistance was due to a Pro106Ser substitution in the EPSPS enzyme. In this study, a combination of genetic inheritance and molecular studies were utilized to investigate if additional glyphosate resistance mechanisms are present in this population. F_1 lines were obtained by crossing glyphosate-susceptible (GS) individuals with GR individuals. The F_1 hybrids were selfed and two separate F_2 lines were analyzed in a dose response. Dose response included GS and GR parental lines as controls. Glyphosate was applied at 0, 105, 210, 420, 840, 1,680, 3,360 and 6,720 g ae ha^{-1}. At 21 DAT, aboveground plant tissue was harvested and then dried and weighed. Leaf material for DNA extraction was harvested from all F_2 plants prior to applying herbicide and these plants were genotyped at the EPSPS locus by PCR amplification of specific alleles (PASA). Neither F_2 population significantly deviated from 1:2:1 inheritance of the three genotypes: homozygous for Pro106 (PP106), heterozygous (PS106), and homozygous for Ser106 (SS106). Dose response curves and GR_{50} values (herbicide dose required to cause a 50% reduction in plant growth) were obtained and compared among the three genotypes and the two parental lines. Based on comparison of GR_{50}s, the R parental line was 3.4-fold resistant to glyphosate relative to the S parental line. A 3.4-fold resistance level also was observed when the SS106 genotype was compared with the PP106 genotype. The identical resistance levels observed in the parental lines and the segregating genotypes indicates that no other resistance mechanism is present in the GR parental line. This conclusion is further supported by the lack of significant difference in the GR_{50} values of the parental GS population (95 g ae ha^{-1}) and the PP106 genotype (119 g ae ha^{-1}), or in the GR_{50} values of the parental GR population (320 g ae ha^{-1}) and the SS106 genotype (399 g ae ha^{-1}). The PS106 genotype showed a response to glyphosate that was intermediate between those of the PP106 and SS106 genotypes, indicating incomplete dominance of the resistance trait. Based on the results of this study, we conclude that the mutation conferring a Pro106Ser EPSPS mutation is solely responsible for glyphosate resistance in the Tennessee GR goosegrass population.

ROLE OF ABSORPTION, TRANSLOCATION, AND EPSPS SENSITIVITY IN THE MECHANISM OF GLYPHOSATE RESISTANCE IN WISCONSIN GIANT RAGWEED. Courtney E. Glettner[1], Christopher R. Van Horn[2], Melinda K. Yerka[3], Philip Westra[2], David E. Stoltenberg*[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Colorado State University, Fort Collins, CO, [3]USDA-ARS, Lincoln, NE (43)

Giant ragweed (*Ambrosia trifida* L.) is one of the most competitive and difficult to manage weed species in Midwestern row cropping systems. Contributing to the challenges of managing giant ragweed is evolved resistance to glyphosate. In 2010, we identified a giant ragweed population that was suspected of surviving repeated exposure to glyphosate on a farm located in Rock County, Wisconsin. Seeds collected from putative glyphosate-resistant (R) and -sensitive (S) plants located on this farm were grown for plant material used in subsequent experiments. In whole-plant dose-response experiments, the glyphosate ED_{50} value (the effective dose that reduced shoot mass 50% relative to nontreated plants) was 6.5-fold greater (P = 0.0076) for R plants [0.86 ± 0.24 (SE) kg ae ha^{-1}] than for S plants (0.13 ± 0.02 kg ae ha^{-1}) 28 d after treatment. Resistant plants did not show a rapid necrosis response to glyphosate. In time-course experiments, absorption and translocation of ^{14}C-glyphosate did not differ between R and S plants over 72 h. In leaf disc shikimate accumulation assays, glyphosate EC_{50} values (the effective concentration that increased shikimate accumulation 50% relative to nontreated leaf tissue) were 4.6- to 5.4-fold greater (P ≤ 0.0004) for R plants than S plants. However, at high glyphosate concentrations (1,000 to 2,000 μM), shikimate accumulation in R plants was similar to or greater than S plants. Partial DNA sequence analysis of *EPSPS* (*5*-enolpyruvylshikimate-*3*-phosphate synthase) found no missense mutations in the Pro_{106} codon in R plants that would confer resistance to glyphosate. The ^{14}C-glyphosate results suggest that glyphosate resistance in Rock County giant ragweed is not conferred by reduced glyphosate absorption or translocation. The similar or greater shikimate accumulation in R compared to S leaf discs at high glyphosate concentrations and the lack of missense mutations in the Pro_{106} codon of R plants suggest that resistance is not likely due to an altered EPSPS target site. However, the possibility remains that the EPSPS target site is less sensitive in R plants compared to S plants at lower glyphosate concentrations. Current research is investigating other possible mechanisms that may confer resistance.

CHARACTERIZATION OF WISCONSIN GIANT RAGWEED RESISTANCE TO CLORANSULAM-METHYL. Stacey M. Marion*, Vince M. Davis, David E. Stoltenberg; University of Wisconsin-Madison, Madison, WI (44)

Effective management of giant ragweed (*Ambrosia trifida* L.) has been threatened by the evolution of resistance to one or more herbicide modes of action in several Midwestern states. In Wisconsin, a giant ragweed population with putative resistance to acetolactate synthase (ALS) inhibitors was identified in a long-term corn-soybean rotation that included cloransulam-methyl use in soybean for broadleaf weed management. After four rotation cycles (8 yr total), field observations suggested that several giant ragweed plants had survived exposure to cloransulam-methyl. Seeds were collected from putative-resistant (R) plants and -sensitive (S) plants located within the same field for use in subsequent experiments. Whole-plant dose-response experiments performed under greenhouse conditions showed that the cloransulam-methyl ED_{50} value (the effective dose of herbicide that reduced shoot mass 50% relative to non-treated plants) for the R accession (92 ± 107 g ai ha^{-1}) was 30-times that of the S accession (3.0 ± 0.7 g ai ha^{-1}) 28 d after treatment. The high level of variability among R plants to cloransulam-methyl was attributed to incomplete segregation of the resistance trait within the sampled population. However, R plants treated with cloransulam-methyl at up to 10 times the labeled rate (176.5 g ai ha^{-1}) showed little or no injury symptomology compared to non-treated control plants. In vivo ALS enzyme bioassays showed that cloransulam-methyl EC_{50} values (the effective concentration of herbicide that inhibited ALS activity 50% relative to non-treated plants) were 10 to 13-fold greater for R than S plants ($P < 0.001$), suggesting that resistance to cloransulam-methyl was conferred by an altered target site. Replacement series experiments conducted under greenhouse conditions showed that total dry shoot biomass accumulation was less for R (120 ± 4.5 g $plant^{-1}$) than S plants (168 ± 6.8 g $plant^{-1}$) ($P < 0.001$). However, total seed mass did not differ between R (20.1 ± 2.0 g $plant^{-1}$) and S (19.5 ± 2.0 g $plant^{-1}$) plants ($P = 0.85$), nor did total seed number between R (430 ± 52 seeds $plant^{-1}$) and S (451 ± 47 seeds $plant^{-1}$) plants ($P = 0.76$). Similarly, seed viability (the percent of intact viable seeds as determined by a tetrazolium assay) did not differ between R (75 ± 1.7%) and S (74 ± 1.4%) plants ($P = 0.91$). These results confirm Wisconsin giant ragweed resistance to cloransulam-methyl and suggest that the mechanism of resistance is an altered ALS enzyme target site. Despite a difference in biomass produced between R and S plants, the lack of difference in fecundity and seed viability suggests that the frequency of the resistance trait is likely to persist over time in the field population.

HPPD RESISTANCE IN NEBRASKA'S WATERHEMP: ENHANCED METABOLISM OR TARGET SITE MUTATION. Maxwel C. Oliveira*[1], Todd Gaines[2], Stevan Z. Knezevic[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Colorado State University, Fort Collins, CO, [3]University of Nebraska-Lincoln, Concord, NE (45)

HPPD-resistant common waterhemp (*Amaranthus rudis*) population has been confirmed in northeast Nebraska in 2012. Previous results with HPPD-resistant waterhemp population from Illinois showed conclusively that resistance was due to enhanced mesotrione metabolism, and the metabolism-based resistance was inhibited by the cytochrome P450 inhibitor malathion (i.e., malathion synergized mesotrione). In 2014, we wanted to assess whether metabolism-based resistance may be part of the resistance mechanism in the Nebraska population. Therefore, we conducted a study with 10 treatments, where five mesotrione doses (0, 1x, 2x, 4x, 8x of label rates) were applied alone or following malathion (2000 g ai ha^{-1}) applied 4 hours prior. Based on visual injury ratings and dry matter, dose response analysis was performed to determine ED_{50} and ED_{90} values for control of about 10 cm tall waterhemp. The level of resistance of mesotrione based on relative dry matter and visual injury of mesotrione were 11x and 12x, respectively. In contrast, the level of resistance in malathion+mesotrione was 19x based on relative dry matter and 21x for visual injury. Corn was severely injured (up to 70% turned white) due the cytochrome P450 inhibition. These results suggested that malathion did not synergize mesotrione activity on HPPD-resistant waterhemp (i.e., lack of increased HPPD-inhibitor control when applied in combination with the metabolic inhibitor). In fact, presence of malathion increased the level of resistance from 12 to 21x (visual injury), and from 11 to 19x (dry matter). These results indicate that the Nebraska population may have a different resistance mechanism, either an enhanced metabolism pathway that is not inhibited by malathion, a different non-target-site mechanism such as reduced translocation, or a target-site mutation in the HPPD gene.

2014 NCWSS WEED CONTEST. Dave Johnson*; DuPont Pioneer, Johnston, IA (46)

No abstract submitted

WEED CONTROL AND CROP TOLERANCE WITH HPPD-TOLERANT SOYBEANS IN NORTHEAST NEBRASKA. 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 (47)

Due to repeated use of glyphosate, there is a continuous increase in the number of glyphosate resistant weeds in the USA, therefore, alternative herbicide tolerant crops, such as HPPD soybeans, are of interest. Field studies were conducted in 2013 and 2014 in Nebraska's soybean cropping system with the mesotrione based products applied PRE and POST in combination with a variety of other herbicides. These included: S-metolachlor+mesotrione, S-metolachlor+fomesafen,S-metolachlor+metribuzin, fomesafen, and metribuzin, applied PRE and S-metolachlor+glyphosate+mesotrione, fomesafen+glyphosate,glyphosate and glufosinate applied POST. S-metolachlor+mesotrione applied PRE provided excellent control (>90%) of waterhemp, lambquarters and velvetleaf. Similar control was also achieved with other treatments.Temporary injury in the form of leaf chlorosis was evident with mesotrione mixes and leaf speckling with fomesafen mixes when applied POST. HPPD soybean exhibited tolerance to mesotrione based products applied both PRE and POST, suggesting that they have a potential for use to control glyphosate resistant waterhemp. However a repeated use of mesotrione based products alone should be avoided to reduce chance for HPPD resistance. In fact, the whole technology of HPPD-tolerant soybean should be used in conjunction with additional modes of actions as part of a Best Management Practice and Stewardship Program.

HERBICIDE OPTIONS TO CONTROL HPPD RESISTANT WATERHEMP IN NEBRASKA. Maxwel C. Oliveira*[1], Jon E. Scott[2], Aaron S. Franssen[3], Stevan Z. Knezevic[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]Syngenta Crop Protection, Seward, NE (48)

Common waterhemp (*Amaranthus rudis*) populations from Nebraska have been confirmed to be resistant to five modes of action (glycine, growth regulators, PSII, ALS, and HPPD). Series of field experiments were conducted in corn during the 2014 season to evaluate various herbicides for control of HPPD-resistant waterhemp with premergence (PRE), postemergence (POST), and PRE followed by POST treatments. The experimental design for all studies was RCBD with treatments replicated three times. One of the best PRE treatments was a tankmix of s-metolachlor+atrazine +mesotrione with acetochlor, which provided 97% control at 60 DAT. POST alone treatments based on glyphosate, and combinations of mesotrione+atrazine with metribuzin provided good control (>80%) at 21 DAT. The combinations of PRE applications of s-metolachlor+atrazine+mesotrione followed by POST applications of glyphosate or glufosinate mixtures provided excellent control (100%) at 32 days after the POST application. Furthermore, PRE applications of acetochlor + atrazine followed by POST applications of topramezone, atrazine and synthetic auxins provided also 100% control at 32 days after the POST treatment. Most of tested herbicide provided very good waterhemp control (>90%), suggesting that excellent herbicides are still available to combat the spread of HPPD-resistant waterhemp in corn.

WEED CONTROL AND CROP TOLERANCE WITH NEW SOYBEAN TRAITS IN NORTHEAST NEBRASKA. Jon E. Scott*[1], Leo D. Charvat[2], John Frihauf[3], Kevin Watteyne[4], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE, [3]BASF Corporation, Research Triangle Park, NC, [4]Bayer CropScience, Lincoln, NE (49)

Weed resistance to glyphosate, ALS and PPO-inhibiting herbicides continue to grow in corn and soybean production systems across the USA, therefore, alternative herbicide choices are needed. While corn has tolerance to dicamba and HPPD-type herbicides, the introduction of dicamba-tolerant and HPPD-tolerant soybeans could provide other options for weed control in soybean growing systems. Field studies with dicamba-tolerant soybean were conducted in 2012, 2013 and 2014 in Nebraska with Engenia™ (BAPMA-dicamba) applied POST following a variety of preemergence herbicides which included: dimethenamid-p, flumioxazin, imazethapyr+saflufenacil, pyroxasulfone, and saflufenacil. Field studies with HPPD-tolerant soybean were conducted in 2012 with isoxaflutole applied PRE and POST in combination with various herbicides including: S-metolachlor, metribuzin, glyphosate, and acetochlor. S-metolachlor+mesotrione was also applied PRE and POST in this study. Dicamba-tolerant soybean exhibited excellent tolerance to BAPMA-dicamba. BAPMA-dicamba applied postemergence at 560 g ai/ha provided 95% control of glyphosate resistant waterhemp; an additional postemergence herbicide will be needed to obtain 100% control. Tank mixes with soil-residuals (dimethenamid-p or acetochlor) did not improve postemergence control, but provided a bit longer lasting control. Most preemergence herbicides provided 100% control of waterhemp (except flumioxazin) for 6-7 weeks. BAPMA-dicamba helped control of glyphosate resistant waterhemp when the residual products did not provide complete control. HPPD-tolerant soybean exhibited excellent tolerance to isoxaflutole applied PRE at the 105 g/ha^{-1} rate and the combination of 70 g/ha^{-1} PRE and 35 g/ha^{-1}POST. This soybean also exhibited tolerance to mesotrione applied PRE. Isoxaflutole at 70 g/ha^{-1} POST and S-metolachlor+mesotrione applied POST did cause minor chlorosis. Isoxaflutole also provided excellent control of waterhemp and velvetleaf. These results indicate potential use of BAPMA-dicamba and isoxaflutole to control glyphosate resistant waterhemp; however repeated use of isoxaflutole alone, or BAPMA-dicamba alone, or their combinations with glyphosate should be avoided to reduce probabilities for HPPD and dicamba resistance. In fact, both technologies, the dicamba-tolerant and the HPPD-tolerant soybeans, should be used in conjunction with additional modes of actions as part of the Best Management Practice and Stewardship Program.

VOLUNTEER GLYPHOSATE RESISTANT SOYBEAN CONTROL IN GLYPHOSATE RESISTANT CORN. Stevan Z. Knezevic*[1], Amit J. Jhala[2], Greg R. Kruger[2], Lowell D. Sandell[3], Maxwel C. Oliveira[4], Jeffrey A. Golus[5], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE, [3]Valent USA Corporation, Lincoln, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]University of Nebraska-Lincoln, North Platte, NE (50)

Most of the Midwestern cropping system is based on a rotation of glyphosate resistant corn and glyphosate resistant soybean. Thus, it is not surprising to see volunteer glyphosate resistant soybean growing in corn and behaving like a weed. Therefore, in Nebraska, we have conducted a series of studies during 2014 season at four locations (Concord, Clay Center, Lincoln and North Platte) with the objective to test several common POST herbicides for volunteer soybean control in corn. Herbicide applications were conducted at the V2-V3 and V4-V6 stages of soybean depending on the location. Data from Concord location suggested that the best control (100%) of V2-V3 soybean at 14 DAT was achieved with: glufosinate, mesotrione+atrazine, tembotrione+atrazine, topramizone+atrazine, or flumetsulam+clopyralid. By 30DAT the following set of treatments also reached the 100% soybean control: diflufenzopyr+dicamba, halosulfuron+dicamba, or thiencarbazone-methyl+tembotrione. Similar results were obtained from other locations. However, taller soybean (V4-V6) were harder to control. The best control (100%) of V4-V6 soybean at Concord at 14 DAT was achieved only with flumetsulam+clopyralid. About 90% control at 14 DAT was achieved with glufosinate, mesotrione+atrazine, tembotrione+atrazine, topramizone+atrazine, or diflufenzopyr+dicamba. Halosulfuron+dicamba and thiencarbazone-methyl+tembotrione reached 90% control by 30DAT. Similar results were obtained from other locations, suggesting that there are herbicide options available for effective control of volunteer soybeans in corn at the cost of $15-25/acre.

HOW DO GROWERS' CURRENT PRACTICES RELATE TO PROPOSED LABEL REQUIREMENTS FOR UPCOMING HERBICIDE-RESISTANT CROP TECHNOLOGIES? Lizabeth Stahl*[1], Lisa M. Behnken[2], Fritz Breitenbach[3], Ryan P. Miller[4], David Nicolai[5]; [1]University of MN Extension, Worthington, MI, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota, St. Paul, MN, [4]University of MN Extension, Rochester, MN, [5]University of MN Extension, Farmington, MN (51)

Upcoming herbicide-resistant crop technologies promise to offer growers an expanded range of tools in weed control, particularly in the control of glyphosate-resistant weeds. At least several of these new tools, however, are planned to come with specific application requirements to help reduce drift and to prevent injury to sensitive crops and vegetation. Application requirements presented to date include the use of drift-reducing nozzles, buffers between treated and sensitive areas, and specific tank cleaning procedures. Efforts have been made to educate growers and agricultural professionals about these application requirements in anticipation of regulatory approval and product launch. To help target educational efforts, there is value in understanding how grower's current practices compare to a technology's application requirements. Data collected at University of Minnesota Private Pesticide Applicator Training sessions and crop meetings through paper surveys (since 2003) and use of Turning Technologies' ResponseCards (since 2008), provide a snap shot of growers' historical practices. On average, over 50% of respondents since 2008 reported they primarily use flat fan nozzles, which would not meet the standards of upcoming herbicide-resistant crop technologies requiring drift-reducing nozzles. Since 2008, an increasing number of growers reported using water and a tank-cleaner when switching from one crop to a susceptible crop, but less than 30% reported checking the herbicide label for instructions on how to clean the tank before switching to a sensitive crop. In 2014, 54% of respondents reported they did not rinse the tank at least three times. Triple rinsing is a planned label requirement for several upcoming herbicide-resistant crop technologies. In surveys conducted in 2011 and 2012, only 46 to 56% of respondents correctly answered questions about the existence of application setback restrictions for two commonly used pesticides, indicating unfamiliarity with label language on setback requirements.

TAKE CONTROL - HERBICIDE SYSTEMS TO CONTROL SOA 2 AND 9 RESISTANT GIANT RAGWEED IN SOYBEAN. Lisa Behnken*, Fritz Breitenbach, Jeffrey L. Gunsolus; University of Minnesota, St. Paul, MN (52)

Over-reliance on postemergence applications of glyphosate has resulted in the reduction of herbicide diversification, a dramatic drop in the use of preemergence herbicides, and the development of resistant weed populations. Dependence on simplistic postemergence herbicide programs has led to weed species resistant to multiple herbicide sites of action, compounding the problem. Diversity of weed management systems must be part of the overall plan to achieve success. Unfortunately, farmers seem reluctant to implement a proactive system until failure occurs on their farm. Even then, the tactic of choice tends to be another herbicide, rather than an integrated system that includes non-chemical approaches. Including a preemergence herbicide is one key strategy in the prevention and management of resistant weed populations. Use of a preemergence herbicide provides many benefits. These include increased yield, additional time to effectively control and target specific weed species, and if planned correctly, the opportunity to introduce an additional herbicide site of action which may extend residual control. Furthermore, the use of a preemergence herbicide decreases weed density, size, species diversity and early-season competition. The end result is a better timed and targeted postemergence herbicide application. The *Ambrosia trifida* population we studied is resistant to herbicide site of action (SOA) groups 9, EPSP synthase inhibitors, and 2, ALS inhibitors. At this point in time, SOA group 10, glutamine-synthetase (GS) inhibitors and SOA group 14, PPO inhibitors, still provide satisfactory AMBTR control in soybean. Over-reliance however, on GS inhibitors and PPO inhibitors without a diversified action plan destines these SOA's for failure. In 2013 and 2014, we conducted trials in southeastern Minnesota comparing herbicide systems using multiple SOA's in an effort to demonstrate effective options to control resistant AMBTR in soybean. Systems included 1) preemergence followed by one or two well-timed postemergence herbicide applications and 2) two well-timed postemergence herbicide applications. This poster demonstrates the challenges associated with achieving an acceptable level of control of a resistant AMBTR population in soybean and the necessity of a preemergence herbicide or two well-timed postemergence herbicide applications to achieve over 90% control of this population. The inclusion of SOA group 14 herbicides in this study, demonstrates the risk of crop phytotoxicity that must be accepted by farmers to achieve satisfactory control.

LATE SEASON WEED ESCAPE SURVEY IDENTIFIES INCREASING NUMBERS OF HERBICIDE-RESISTANT *AMARANTHUS SPP*. IN WISCONSIN. Thomas R. Butts*[1], Ross A. Recker[2], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Monsanto Company, Monmouth, IL (53)

Herbicide-resistant weeds are a significantly increasing threat to current agricultural production systems. Pigweeds (*Amaranthus spp.*), specifically common waterhemp (*Amaranthus rudis Sauer*) and Palmer amaranth (*Amaranthus palmeri S. Wats.*), account for a large portion of these current challenges in the United States. These two weed species have developed herbicide resistance to more than five different sites-of-action, with resistance to at least one site-of-action occurring in 32 states. Wisconsin currently has one confirmed ALS-resistant biotype of common waterhemp, but there are indications of further resistance problems throughout the state. In 2012, the *Late-Season Weed Escape Survey in Wisconsin Corn and Soybean Fields* was initiated. One of the main objectives was to identify potential herbicide-resistant weeds. Fields containing potential herbicide-resistant weeds were identified through grower communication, field history, and in-field sampling. Five, ten, and six separate common waterhemp populations were identified as potentially herbicide-resistant in 2012, 2013, and 2014, respectively. Moreover, these surveys helped identify the first case of Palmer amaranth occurrence in Wisconsin in 2013, and identified a second population in 2014, both with suspected herbicide resistance. Twelve common waterhemp populations were tested for glyphosate resistance. Currently, one Palmer amaranth population is being screened for glyphosate resistance, while the second population is being screened for multiple resistances to glyphosate, tembotrione, and cloransulam-methyl herbicides. To screen for herbicide resistance, seed heads from all populations were collected, dried, and threshed for use in whole plant herbicide dose response bioassays. Progeny were grown, and seven to ten plants per herbicide rate plus the appropriate adjuvants were sprayed when four inches tall. Glyphosate rates used for common waterhemp were 0, 0.22, 0.43, 0.87, 1.74, 3.48, and 6.96 kg ae ha^{-1}. Glyphosate rates used for Palmer amaranth were 0, 0.0087, 0.087, 0.87, and 8.7 kg ae ha^{-1}. Tembotrione rates used were 0, 0.023, 0.046, 0.092, 0.184, 0.368, and 0.736 kg ae ha^{-1}. Cloransulam-methyl rates used were 0, 0.00018, 0.0018, 0.018, 0.18, 1.8, and 9 kg ae ha^{-1}. For common waterhemp, two separate screenings were conducted, and plant dry biomass data were collected 28 days after application. The effective glyphosate dose needed to reduce plant dry biomass 90% (ED_{90}) was determined for the putative resistant and susceptible biotypes. Common waterhemp populations from Eau Claire and Pierce Counties in Wisconsin were confirmed glyphosate-resistant. The ED_{90} values for the Eau Claire County, Pierce County, and susceptible populations were 3.91, 5.16, and 0.40 kg ae ha^{-1}, respectively. This indicated a 10-fold resistance for the Eau Claire County population and a 13-fold resistance for the Pierce County population. Preliminary results for the Palmer amaranth populations from Dane and Iowa Counties in Wisconsin illustrate high potential for herbicide resistance. Visual control ratings were below 90% for the Iowa County population at both the 0.092 kg ae ha^{-1} rate and 0.018 kg ae ha^{-1} rate of tembotrione and cloransulam-methyl, respectively. Furthermore, visual control ratings of the Dane County population were below 90% and all ten plants survived the 0.87 kg ae ha^{-1} glyphosate rate. Further research will be conducted on the Palmer amaranth populations to investigate potential resistance within the state of Wisconsin.

MANUAL FOR PROPANE-FUELED FLAME WEEDING IN CORN, SOYBEAN, AND SUNFLOWER. Stevan Z. Knezevic*[1], Avishek Datta[2], Chris Bruening[3], George Gogos[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Asian Institute of Technology, Bangkok, Thailand, [3]University of Nebraska-Lincoln, Lincoln, NE (54)

Flame weeding is an approved method for weed control in organic cropping systems, with the potential for use in conventional agriculture. From 2006-2012 we have conducted a series of over 40 studies, which were funded by PERC and other sources (eg. USDA). This extensive work resulted in over 20 journal and proceeding articles about crop tolerance to heat and weed control with flame weeding in field corn, popcorn, sweet corn, sunflower, soybean, sorghum and winter wheat. We compiled the above research information into a training manual that describes the proper use of propane fueled flaming as a weed control tool in six agronomic crops (field corn, popcorn, sweet corn, soybean, sorghum, and sunflower). 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.propane.com/uploadedFiles/Propane/Agriculture/Safety/PropaneFueledFlameWeeding.pdf

USING GROWER SURVEY RESPONSES TO ASSESS HERBICIDE RESISTANCE ISSUES AND EDUCATIONAL NEEDS. Lizabeth Stahl*[1], Lisa M. Behnken[2], Fritz Breitenbach[3], David A. Nicolai[4], Ryan P. Miller[5]; [1]University of MN Extension, Worthington, MI, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota, St. Paul, MN, [4]University of MN Extension, Farmington, MN, [5]University of MN Extension, Rochester, MN (55)

The incidence of glyphosate-resistant weeds has been increasing throughout Minnesota. To help estimate the extent of control issues with glyphosate and to identify the weed management strategies growers are actually using, survey data was collected through use of the Integrated Pest Management (IPM) Assessment tool at Private Pesticide Applicator training sessions conducted across southern Minnesota. Grower responses were initially collected through paper surveys starting in 2003, but paper surveys were phased out after 2008 when Turning Technologies' ResponseCards (i.e. clickers) were brought into use. Results of the assessment demonstrate that an increasing percent of growers are reporting decreased control with glyphosate. When asked if glyphosate worked as well today as it did when they first used it, an average of 87% of respondents in 2014 reported it did not. In comparison, 55% of the respondents in 2009 reported it did not. When growers were asked if they believed they had glyphosate-resistant weeds on their farm, the percent of growers reporting "yes" has been increasing over time. In 2008 31% of respondents reported they believed they had glyphosate-resistant weeds on their farm, while in 2014, 68% of respondents believed they did. Although historically growers reported wide use of a postemergence (POST)-only herbicide system (60 to 71% reported using a POST-only system in soybeans and 40 to 50% reported using a POST-only system in corn from 2009 to 2011) in recent years, a significant percent of growers reported they were planning to use a preemergence (PRE) herbicide (65 and 77% indicated they were going to use a PRE in soybean and 78 and 79% indicated they were planning to use a PRE in corn in 2013 and 2014, respectively). Use of the IPM Assessment tool has helped enhance PPAT sessions and response of participants to use the clickers has been overwhelmingly positive. Besides adding educational value to the PPAT program, information collected through the IPM Assessment tool has been useful in targeting educational research and outreach efforts.

STEVIA TOLERANCE TO HERBICIDES. Donald Penner*, Jan Michael; Michigan State University, East Lansing, MI (56)

No abstract submitted

SCREENING OF HERBICIDES FOR SELECTIVE WEED CONTROL IN AFRICAN MARIGOLDS (*TAGETES ERECTA*). Katie J. Demers*[1], Robert Hartzler[1], John A. Greaves[2], Norman P. Cloud[2]; [1]Iowa State University, Ames, IA, [2]Kemin Industries Inc, Des Moines, IA (57)

The high cost of African marigold (*Tagetes erecta*) production has resulted in most commercial production being located outside of North America. Selective herbicides provide an alternative method to control weeds and reduce production costs. African marigold was screened for tolerance to 11 preemergence and 16 postemergence herbicides in the greenhouse to identify candidate herbicides for field evaluation. Each herbicide was applied at 1, 2, and 4 times the labeled rate. A 1:1 mix of commercial potting mix and soil was used for evaluating preemergence herbicides. The soil mix was placed in 200 cm^2 trays and then 12 marigold seeds were planted at a 0.75 cm depth. Herbicides were sprayed on the growing media surface and then moved into the profile with an equivalent of 1.3 cm rainfall. Injury ratings and emergence counts were taken for approximately 15 days after planting. All preemergence experiments consisted of six replicates and were repeated twice. Postemergence herbicides were applied to two 8 to 13 cm tall marigold plants grown in commercial potting mix contained in 10.4 cm diameter pots. Postemergence experiments used four to six replications and with the exception of one, were replicated twice. Injury ratings began five days after application and concluded with plant death or recovery. A scale of 1 to 9 was used, with 1 indicating no injury and 9 indicating plant death. Pendimethalin, bensulide, trifluralin, and acetochlor applied preemergence and topramezone and encapsulated acetochlor applied postemergence resulted in low crop injury. Percent emergence for the untreated controls in the preemergence experiments averaged 62 percent. Pendimethalin resulted in 63, 63, and 61 percent emergence with injury of 1.5, 1.8, and 1.9 at the 1, 2, and 4X rate, respectively. Bensulide resulted in 75, 69, and 68 percent emergence with injury of 1.4, 1.8 and 1.8. Trifluralin resulted in 52, 49, and 51 percent emergence with injury of 2.8, 2.4, and 3.0. Acetochlor resulted in 65, 64, and 63 percent emergence with injury of 6.1, 7.3, and 6.1. Topramezone applied postemergence caused injury of 3.5, 4.1, and 4.4 at the 1, 2, and 4X rate, respectively. A tank mix of the three rates of topramezone and 1.26 kg ha acetochlor resulted in postemergence injury between 3.1 and 4.8 whereas acetochlor alone resulted in injury of 2.1. African marigold emergence was not affected by bensulide, pendimethalin, or trifluralin in field trials, nor was there significant visual injury. Topramezone, acetochlor, and a tank mix of three rates of topramezone with two rates of acetochlor resulted in significant injury; however, plants treated with label rate applications of topramezone, acetochlor, and a tank mix of topramezone and acetochlor recovered within three weeks after application.

EFFECT OF SIMULATED GLYPHOSATE DRIFT ON SEED PIECES FROM FOUR POTATO PROCESSING CULTIVARS. Collin P. Auwarter*[1], Harlene M. Hatterman-Valenti[2]; [1]ndsu, fargo, ND, [2]North Dakota State University, Fargo, ND (58)

A field study was conducted to determine the carryover effect on potatoes grown for seed and planted the season following simulated glyphosate drift on four processing cultivars (Bannock Russet, Ranger Russet, Russet Burbank, and Umatilla Russet). In 2013, the four cultivars were planted on June 12 at the Northern Plains Potato Growers Association irrigation research site near Inkster, ND. Sub-lethal rates of glyphosate were applied to mother plants at one-half, one-quarter, and one-eighth the lowest labeled rate of 0.43 kg ae ha^{-1} glyphosate at the tuber initiation (TI), early tuber bulking (EB), and late tuber bulking (LB) stages. Potatoes were harvested October 23, graded for yield and quality, and stored for planting in 2014. On May 28, 2014, individual seed pieces from 20 randomly selected tubers within each treatment were planted. Potato stand counts were recorded mid-July and mid-August. Plots were harvested mid-October and graded shortly after harvest. All cultivars had slower plant emergence when glyphosate was applied to mother plants, regardless of the application timing. In general, potato yield was inversely related to the glyphosate rate. The lowest 'Russet Burbank' yield occurred when glyphosate was applied at the TI stage, while the lowest yield with the other three cultivars was when glyphosate was applied later at either the EB or LB stages. 'Bannock' was the most sensitive cultivar with seed from plants receiving any sub-lethal glyphosate rate yielding ≤ 65% of the untreated. The remaining three cultivars were less sensitive to glyphosate drift and had at least one glyphosate drift treatment with similar or greater tuber yield compared to the untreated yield. Plants treated with 0.06 kg ha^{-1} glyphosate at the LB stage produced seed that had the highest yields. Seed from plants receiving 0.21 kg ha^{-1} glyphosate, regardless of the application timing and cultivar had lower tuber counts compared to the untreated. Results suggested that 'Ranger Russet' was the least sensitive cultivar to the carryover effect on potatoes grown for seed and planted the season following simulated glyphosate drift.

BIOLOGICAL CONTROL OF GARLIC MUSTARD IN NORTH AMERICA. Jeanie Katovich*, Roger L. Becker; University of Minnesota, St. Paul, MN (59)

No abstract submitted

IMPACT OF NATIVE PRAIRIE FUNCTIONAL GROUPS ON PERSISTENCE OF CANADA THISTLE. Roger L. Becker*[1], Milt Haar[2], Lee Klossner[3]; [1]University of Minnesota, St. Paul, MN, [2]US Department of Interior, Interior, SD, [3]University of Minnesota, Lamberton, MN (60)

No abstract submitted

JAPANESE STILTGRASS CONTROL IN MANAGED WOODLANDS. Joe Omielan*, Michael Barrett; University of Kentucky, Lexington, KY (61)

Japanese stiltgrass (*Microstegium vimineum*) is a sprawling, dense, mat-forming annual grass. It is very shade tolerant but will quickly take advantage of extra sunlight and is common in forest edges, roadsides, trailsides, and disturbed areas such as skid trails (timber harvest). It's a prolific seed producer, the seed is readily spread by humans and machinery, and the seed bank can remain viable for 3 years. It competes with and reduces regeneration of desirable species in managed woodlands. Successful management of stiltgrass requires control of the plants before seed production and extended control of the plants coming up from the seedbank. What are some of the selective herbicide control options and how effective are they? This study was initiated in September, 2013 along a skid trail in a recently selectively harvested forest in Fort Knox to answer the questions asked above. Most herbicide treatments were applied at 187 L/ha onto 1.5 m by 6 m plots on Sept. 24, 2013. The early summer treatment was applied on July 15, 2014. The 9 treatments were arranged as a randomized complete block design with 3 replications. The treatments included the following products (active ingredients): imazapic, fluaxifop, glyphosate, aminopyralid, aminocyclopyrachlor + metsulfuron, sulfometuron + metsulfuron, prodiamine, and pendimethalin by themselves as well as in combinations for postemerge and preemerge control. All treatments included a non-ionic surfactant at 0.5% v/v. Visual assessments of percent stiltgrass control were done 14 (10/8/2013), 294 (7/15/2014), and 393 (10/22/2014) DAT (days after initial treatment). Data on green vegetative cover (0-100%) were collected 294 and 393 DAT. Most of the treatments, except for imazapic, had stiltgrass control greater than 96% 294 DAT. However, the imazapic and fusilade treatments had the most green vegetative cover for the sprayed plots 294 DAT. The sulfometuron + metsulfuron, fluazifop, and prodiamine treatments still had the greatest control (89 – 97%) 393 DAT. However, the imazapic and aminopyralid treatments had the same proportion of green vegetative cover as the control plots 393 DAT. Final assessments will be done in 2015. There are a number of herbicide options which are selective and effective in stiltgrass control.

MANAGEMENT OF CALLERY PEAR (*PYRUS CALLERYANA*) ON URBAN ROADSIDES. Carey Page*[1], E. Scott Flynn[2], Reid Smeda[1]; [1]University of Missouri, Columbia, MO, [2]Dow Agrosciences, Lee's Summit, MO (62)

Beginning in the 1930's, cultivars of Callery pear (*Pyrus Calleryana*) cultivars were introduced as a landscape tree throughout the Midwest. Over the past two decades, cultivars have hybridized with other *P. calleryana* cultivars. Resultant fruit contain fertile seeds that birds have spread throughout urban landscapes and along roadsides. Escaped plants are spread quickly and should be considered invasive; best management practices are currently unknown. Completely randomized studies were established in Columbia and St. Louis, MO to examine plant response to five foliar (187 Lha^{-1} spray volume) and one basal bark herbicide application. In

August of 2013, applications were made on 1.5 to 2 meter tall trees. At 30 days after treatment (DAT), basal versus foliar applied triclopyr resulted in up to 90 and 80% visual control, respectively at both locations. Specifically, aminopyralid + metsulfuron resulted in up to 52% and 50% control for Columbia and St. Louis respectively. The addition of triclopyr to aminopyralid versus metsulfuron resulted in similar control at both locations. By one year after treatment, basal applied triclopyr resulted in 100% control at both locations. Foliar applied picloram + fluoroxypyr, aminopyralid + triclopyr, or aminopyralid + metsulfuron resulted in an average of 85, 69, and 87% respectively across both locations. Regrowth at the base of all foliar treated plants was evident, suggesting sequential applications will be needed for full control; no treated plants exhibited fruit. Callery pear can be managed with numerous herbicides typically associated with brush control.

CONFIRMATION OF GLYPHOSATE-RESISTANT COMMON RAGWEED IN NEBRASKA. Lucas Baldridge*[1], Andre Silva[1], Rodrigo Werle[1], Lowell D. Sandell[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (63)

Common ragweed is a competitive weed in corn and soybean production. With the extensive use of glyphosate in glyphosate-resistant crops, glyphosate-resistant populations of common ragweed have surfaced. There have been confirmed glyphosate-resistant common ragweed populations in 14 states dating back to 2004. The objective of this study was to evaluate a putative glyphosate-resistant population of common ragweed found in Gage County, NE in a corn-soybean production system. Seed was collected in the fall of 2013 from this system and a greenhouse dose response study was conducted in 2014 to determine if the population was resistant. The experiment was conducted in a randomized complete block design with two runs and six replications. A known susceptible population was compared to the putative glyphosate-resistant population in the study. Dose response studies were conducted with nine different glyphosate rates 0, 280, 560, 840, 1120, 1680, 2240, 4480, and 8960 g ae/ha applied at pooled across two weed heights (8 and 16 cm). Visual estimations of injury and dry matter data were collected at 28 DAT. Glyphosate-resistance was determined by the I_{50} and I_{90} values of the population. A log-logistic function was fit to the visual estimations of injury and dry matter reduction data and the I_{50} and I_{90} were determined using drc package in R software. The putative glyphosate-resistant population required at 11 and 20 times and 15 and 6 times more herbicide to obtain 50% and 90% reduction in visual injury and dry weight reduction, respectively. Glyphosate-resistance was confirmed in common ragweed in Nebraska and growers in the state should be aware that this could be a problem going forward and manage common ragweed populations appropriately.

CRITICAL DURATION OF GRASS WEED INTERFERENCE IN GRAIN SORGHUM. Gared E. Shaffer*[1], J. Anita Dille[2]; [1]Kansas State University, Manhattan, KS, [2]Agronomy Department, Kansas State University, Manhattan, KS (64)

The anticipated release of Inzen-traited grain sorghum hybrids by 2016 provide an opportunity to control grassy weeds POST with the ALS-inhibiting herbicide (Zest), which requires more information on grass weed impacts on grain sorghum. My objectives are 1) Determine the critical duration of grass weed competition in grain sorghum with different crop row spacing's and seeding rates, and 2) Evaluate the timing of grass weed removal on grain sorghum yield. This study was established at the Agricultural Research Center at Hays, KS. Four main plots were established that combine two grain sorghum row spacings of 25 and 75 cm and two seeding rates of 120,000 and 150,000 seed per ha. Within each of these main plots, seven treatments were established including: weed-free all season using PRE herbicide, weed-free all season (by hand), weedy for 2, 3, 4, and 5 weeks after crop emergence, and weedy throughout the growing season. This results in a total of 28 plots per replication, with four replications. Each sub-plot was 3 m wide and 9 m long. The focus is on these grasses: giant and/or yellow foxtail, large crabgrass, and barnyardgrass. With approximately 1,500 seeds per weedy subplot and broadleaf weeds removed throughout season. At the allotted time (2, 3, 4, or 5 weeks after crop emergence), weeds from the appropriate plots were hand harvested from a 0.5 m by 0.5 m quadrat to document density, and biomass of grassy weeds. LAI was received from two representative plants from every subplot. At harvest we collected 1m by 9 m sorghum heads from every subplot and threshed. Also a 1 m by 1 m quadrat to document crop biomass was taken. Most grass weed competition happened with the 76-cm rows and the greatest competition was within 76-cm rows and 120,000 seeding rate. Grass weed interference for five weeks did not affect sorghum yield as much as anticipated. There was loss of sorghum leaf area as grass competition continued for 20 weeks. On average in 25-cm rows there was a negative effect on grass biomass vs. 76-cm rows that had greater grass biomass. Removing grass competition over a two to five week period after crop emergence will maintain yields.

INFLUENCE OF TILLAGE SYSTEMS ON GLYPHOSATE-RESISTANT WATERHEMP IN INDIANA. Joseph M. Heneghan*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (65)

Waterhemp (*Amaranthus tuberculatus* var. *rudis*) is a small-seeded broadleaf and has been observed to germinate at shallow soil depths. No-tillage systems leave weed seeds on top of the soil surface, while conventional tillage systems bury the seed at depths greater than what is favorable for germination. A field experiment was conducted to compare the effect of no-tillage versus conventional chisel plow/field cultivator on waterhemp emergence throughout the season with two different herbicide treatments in soybean. Glufosinate-resistant soybeans were planted May 8 in 76 cm rows at 345,000 seeds ha^{-1}. Herbicide treatments consisted of a single POST 21 DAP of glufosinate at 595 g ai ha^{-1} compared to a PRE of flumioxazin at 90 g ai ha^{-1} fb a POST 21 DAP of glufosinate at 595 g ai ha^{-1} and s-metoloachlor at 1395 g ai ha^{-1}. Waterhemp emergence was counted bi-weekly from two $1m^2$ quadrats within each plot and any emerged seedlings were removed at the time of counting. Precipitation, air and soil temperature at 3 cm was recorded throughout the duration of the experiment, which concluded at the R6 soybean growth stage. Soil moisture was consistently higher in the no-tillage treatments throughout the growing season while soil temperatures were similar. Cumulative waterhemp emergence was higher in the no tillage treatments and total waterhemp emergence was higher in the non-residual herbicide treatments with. Peak emergence occurred 14 days sooner in the no-tillage plots compared to the conventional. Waterhemp emergence declined sharply 55 DAP.

WEED SUPPRESSION WITH NARROW ROWS AND HIGH SEEDING RATES IN GRAIN SORGHUM. Cade A. Hewitt*[1], J. Anita Dille[2], Phillip W. Stahlman[3], Curtis R. Thompson[1]; [1]Kansas State University, Manhattan, KS, [2]Agronomy Department, Kansas State University, Manhattan, KS, [3]Kansas State University, Hays, KS (66)

Weed control in grain sorghum has always presented a challenge to producers in the semi-arid Great Plains. Producers often utilized tillage, preemerge herbicides, and crop rotation to maintain weed control in grain sorghum production. Cultural control tactics such as manipulation of row spacings and seeding rates can also be effective control methods. Through the manipulation of cultural practices, a reduction in weed control inputs is possible. The objective of this study is to determine the row spacing and plant population that maximizes yield while reducing weed pressure. Grain sorghum row spacings of 25, 51, and 76-cm and established plant populations of 75,000, 100,000, 125,000, and 150,000 plants per hectare were investigated at Manhattan and Beloit, KS in 2013. Grain sorghum growth and yield response were studied in response to natural weed communities. Grain sorghum in Beloit planted on wide-row spacing yielded 8422 kg/ha and outyielded medium and narrow row spacings by 637 and 662 kg/ha, respectively. Grain sorghum populations of 125,000 plants per acre outyielded 75,000, 100,000, and 150,000 plants per hectare by 876, 387, and 489 kg/ha, respectively. Wide row spacings produced 2729 g/m² grain sorghum biomass at growth stage 6 per m² and more than the medium and narrow row spacings by 599 and 461 g/m², respectively. Results indicated that wide row spacings and 150,000 plants per hectare outyielded all other treatments under a low weed pressure environment. Future research could look at a consistent weed density across all treatments and the optimal planting population and row spacing could be determined for other specific environments across the semi-arid Great Plains.

POPULATION-DEPENDENT DOMINANCE OF THE R-ALLELE IN *AMARANTHUS TUBERCULATUS* RESISTANT TO PPO INHIBITORS. R. Joseph Wuerffel*[1], Bryan Young[2]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN (67)

Evolved resistance to herbicides inhibiting protoporphyrinogen oxidase (PPO-R) in waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer (syn. *rudis*)] is inherited via a single dominant gene (*PPX2L*), missing a glycine at the 210^{th} amino acid position (ΔG210). The PPO-R allele is reported to display incomplete dominance (D = 0.76; $D > 0$ = incomplete dominance; $D < 0$ = incomplete recessivity), with described GR_{50} values of 21, 12.5, and 0.4 g ai ha^{-1} of lactofen for homozygous-resistant (RR), heterozygous-resistant (RS), and homozygous-susceptible (SS) individuals, respectively. Accordingly, this suggests that there is a limited advantage to having one or two copies of the PPO-R allele, given that RS individuals behave more similarly to RR individuals. However, PPO-inhibiting herbicide efficacy has not been studied on RS individuals in multiple waterhemp populations resistant to the associated herbicides. Variable sensitivity to PPO inhibitors among waterhemp populations may cause dominance of the R-allele to vary. A genotypic and phenotypic screen of multiple waterhemp populations resistant to PPO-inhibiting herbicides could reveal population-dependent dominance of the R-allele, as well as improve understanding of the association between the frequency of the R-allele and phenotypic resistance. To investigate the sensitivity of RS individuals to PPO-inhibiting herbicides from multiple populations, soil seed bank samples were collected from 13 waterhemp populations that survived a foliar-applied PPO-inhibiting herbicide in 2013. Three replications of 20 plants from each population were sprayed with lactofen (110 g ai ha^{-1}) + COC (1% v/v). Non-treated plants were included for comparison and the experiment was performed twice. Prior to lactofen application, plants were sampled for genotyping via an allele-specific TaqMan® assay to determine if plants were RR, RS, or SS for resistance to PPO-inhibiting herbicides. Based on relative dry weight data harvested 14 days after treatment, RR individuals consistently had a greater dry weight than SS individuals; however, comparisons with RS individuals varied by population. The mean dominance value across all populations was 0.56; however, dominance was variable, with values ranging from -0.25 to 1.15. Variable levels of dominance among populations implies that PPO-inhibiting herbicides may provide adequate efficacy of RS individuals in select populations; however, only two populations expressed a lack of dominance. Furthermore, these data revealed that RS individuals were rare. Taken together, these data suggest that targeting waterhemp that is heterozygous for PPO-R is likely not a viable resistance management strategy; however, exploring interactions with different PPO-inhibiting herbicides, varying herbicide rates, or various plant heights may reveal different results, thereby warranting further investigation.

CAN FOLIAR-APPLIED GIBBERELLIC ACID INFLUENCE SEX DETERMINATION OR PISTILLATE FLOWER MORPHOLOGY IN *AMARANTHUS TUBERCULATUS*? Brent Sunderlage*[1], R. Joseph Wuerffel[1], Bryan Young[2]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN (68)

Waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer (syn. *rudis*)] is a problematic agronomic weed that has become progressively more difficult for growers to control due to multiple herbicide resistance. The dioecious nature of waterhemp and capacity to produce up to 1.2 million seeds allows for the accumulation of herbicide-resistant seeds in the soil seed-bank following failed herbicide applications. Gibberellic acid (GA_3) is a plant growth hormone that has been shown to promote masculine flower characteristics in dioecious hemp, spinach, and cucumber when exogenously applied. This research examines the effects of foliar applied GA_3 on phenotypic sex ratios, changes in pistillate flower morphology, and seed production in glyphosate-resistant waterhemp. Plants were grown under greenhouse conditions, and GA_3 was applied at 10, 100, and 1,000 ppm at two different flowering intervals. Applications of GA_3 were performed every three days beginning at 30 cm in plant height until visible bud emergence or until sex was determined by the emergence of stigma or anthers. Applications were made by hand misting until leaf run-off. Male and female plant ratios were recorded, and estimated ovary size was measured three weeks after bud emergence. Estimated ovary size was quantified with stereomicroscopy and computer image analyzing software (Image J®). Plants were harvested at 11 weeks after bud emergence or at earliest senescence; then seeds were collected and quantified. Sex determination was not influenced by the rate of GA or duration of applications. In addition, ovary size was not reduced using 10 or 100 ppm GA_3 rates, regardless of duration of application. However, GA_3 applied at 1000 ppm significantly reduced ovary size in both flowering intervals. Seed production was reduced by 72% relative to the non-treated control when 1000 ppm of GA_3 was applied until sex determination. Foliar-applied GA_3 at high concentrations may offer future utility to growers as a tool to limit the propagation of herbicide-resistant waterhemp seed following failed herbicide applications.

CONTROL OF SEVERAL SOUTHERN ILLINOIS PALMER AMARANTH POPULATIONS WITH FOMESAFEN AND LACTOFEN. Kayla N. Wiedau*, R. Joseph Wuerffel, Joseph L. Matthews, Ronald F. Krausz; Southern Illinois University, Carbondale, IL (69)

Glyphosate-resistant Palmer amaranth [*Amaranthus palmeri* (S. Wats)] is becoming increasingly prevalent in Midwestern row crop production; consequently, many soybean growers will be forced to rely heavily on PPO-inhibiting herbicides to achieve adequate control of this weed species. Using the most effective herbicide is important for preventing yield loss and limiting further spread of herbicide-resistant weed biotypes; therefore, understanding which foliar-applied PPO-inhibiting herbicide provides the greatest efficacy on Palmer amaranth is critical. Greenhouse experiments were established using four Palmer amaranth biotypes, two glyphosate-resistant (Madison and Massac Co. Illinois), and two glyphosate-susceptible (St. Clair and Franklin Co. Illinois) to evaluate the efficacy of two PPO-inhibiting herbicides: fomesafen (Flexstar®) and lactofen (Cobra®) commercially formulated with proprietary adjuvants (1x = 396 and 220 g ai ha-1, respectively). Applications were made at 0.25, 0.5, 1, 2, and 3X rates when plants reached a height of 10 to14 cm; COC at 1% v/v was included. Visually assessed herbicide efficacy ratings and plant heights were recorded at 3, 7, and 14 days after treatment (DAT). Aboveground biomass was harvested at 14 DAT, dried and weighed. Mean relative dry weights indicated that fomesafen offered 29% greater control than lactofen averaged across populations and rates. Additional experiments were conducted to explore the effects of adjuvants on the efficacy of these herbicides. Two fomesafen-containing herbicides, one commercially formulated with a premium adjuvant system (Flexstar®) and one without (Reflex®), and lactofen (Cobra®) were sprayed at 1x rates on all four populations. Results indicated that fomesafen formulated with a premium adjuvant had a lower mean relative dry weight across all populations than the fomesafen formulated without an adjuvant or the lactofen. There were no differences between fomesafen without an adjuvant and lactofen when comparing mean relative dry weight. The three aforementioned herbicides were also sprayed at 1x rates across all populations with 28% UAN at 4% v/v added to the fomesafen formulated without an adjuvant and the lactofen. Visually assessed herbicide efficacy ratings were equal across herbicides (97 to 99%), indicating that the addition of an enhanced adjuvant system may be needed to provide adequate control of Palmer amaranth with a foliar-applied PPO inhibitor. Therefore, when considering options for postemergence control of glyphosate-resistant or glyphosate-susceptible Palmer amaranth, the appropriate adjuvant with the PPO-inhibiting herbicide is required to ensure adequate control of Palmer amaranth.

INFLUENCE OF PLANT HEIGHT AND GROWTH TEMPERATURE ON GLYPHOSATE EFFICACY IN COMMON LAMBSQUARTERS. Randy D. Degreeff*[1], Mithila Jugulam[2], Amar S. Godar[2], J. Anita Dille[3]; [1]Kansas State University, SALINA, KS, [2]Kansas State University, Manhattan, KS, [3]Agronomy Department, Kansas State University, Manhattan, KS (70)

Common Lambsquarters (*Chenopodium album L.*) is an annual broadleaf weed in the goosefoot family (*Chenopodiaceae*) that competes with more than 40 crop species around the world and is a principal weed in corn and soybean crops in the United States.   Common lambsquarters generally are susceptible to glyphosate at early seedling stages, but control is highly variable at later growth stages. Previous research related to the effect of temperature on overall glyphosate efficacy has been mixed, with some studies demonstrating increased efficacy in cooler environments, while others suggest no relationship between temperature and glyphosate efficacy. Greenhouse and growth chamber experiments were conducted to determine the influence of plant height and growth temperature on glyphosate efficacy in common lambsquarters. Greenhouse plants were treated with glyphosate at a field dose (1X) of 840 g ae/ha when they were 5-7, 10-12, 15-17 or 19-21 cm tall. Common lambsquarters grown in growth chambers maintained at day/night temperatures of 25/15°C, 32.5/22.5°C, or 40/30°C were treated with 0-, 0.125-, 0.25-, 0.5-, 0.75, 1.0-, and 2.0-X rates of glyphosate (where X is 840 g ae/ha) when plants were 10-12 cm tall. Visual injury as well as biomass were determined 2 weeks after glyphosate treatment. Results suggest that the common lambsquarters plants at early growth stages of 5-7 cm were more susceptible to glyphosate as opposed to larger plants of 15-17 or 19-21 cm. Furthermore, common lambsquarters was also more susceptible to glyphosate when grown under lower temperatures of 25/15°C than higher temperatures of 32.5/22.5 or 40/30°C with ED_{50} for mortality were 68.37, 411, and 412 g ae/ha, respectively. Experiments are in progress to determine the physiological basis for improved glyphosate efficacy under lower temperature. The results of this research suggest that in order to improve efficacy and achieve maximum control of common lambsquarters, glyphosate should be applied early in the season when plants are small and temperatures are cooler.

IMPORTANCE OF EMERGENCE DATE ON THE DEVELOPMENT OF PALMER AMARANTH (*AMARANTHUS PALMERI*). Heidi R. Davis*, Reid Smeda; University of Missouri, Columbia, MO (71)

Amaranthus species such as Palmer amaranth (*Amaranthus palmeri*) emerge throughout the growing season, with plants competitively reducing crop yield as well as adding significantly to the soil seed bank. Growers manage early season Palmer amaranth to protect crop yield, but later season seedlings are often poorly controlled. Research is needed to better describe the relationship of emergence date to plant growth and seed production. At a research farm in southeast MO, Palmer amaranth seedlings were allowed to emerge from the existing soil seed bank at five defined emergence timings from mid-May through mid-September. Weekly through plant senescence, the heights and number of nodes were recorded from six plants in each of five replications. As plants initiated flowering, up to 70 plants across the trial at each emergence date were observed to assess the ratio of male to female plants. For 2013, 43 to 55% of the population was female and sex was not related to emergence date. Six plants from each replication and planting date were harvested when 80% of the seed was visually mature. Seed production for plants emerging in mid-May averaged 115,303 seeds. For plants emerging in early June, late June, and mid-July, average seed production was 141,422, 84,316 and 28,940 seeds, respectively. No seeds were found on plants emerging in September (about 6 weeks before an expected frost). To assess the potential strength of seeds, the number of seeds comprising a kilogram of seed was determined. Seed number per kilogram weight fluctuated throughout the season with 2,281,946, 2,625,648, 2,417,166 and 2,164,542 seeds for plants emerging mid-May, early June, late June and late July, respectively. In our study, the ratio of male to female Palmer amaranth does not appear related to emergence date, and seeds produced on early versus later season emerging plants are similar in weight. Control of later emerging Palmer amaranth is necessary to preclude significant additions to the soil seed bank.

ASSOCIATION BETWEEN SEED DORMANCY AND RESISTANCES TO ALS AND PPO INHIBITORS IN WATERHEMP. Patrick J. Tranel[1], Chenxi Wu*[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois at Champaign-Urbana, Urbana, IL (72)

Seed dormancy and herbicide resistance are both traits that contribute to the success of weeds in cropping systems. However, relatively few studies have investigated the association between weed seed dormancy and herbicide resistance. In this study, we investigated the linkage between seed dormancy and resistances to ALS and PPO inhibitors in common waterhemp through both greenhouse and laboratory experiments. Four populations were used in this study, one is an F_2 population (APF2) derived from a cross between a plant resistant to both ALS and PPO inhibitors and a plant that is sensitive to both. The other three populations are experimental populations (G1a, G3a, G4a) segregating for resistances to herbicides spanning five modes of action, including ALS and PPO inhibitors. In the laboratory study, we separated highly dormant (HD) seeds from low dormant (LD) seeds through a standard 14-day germination test (alternating temperature), with seeds germinated within 48 hours designated as LD seeds. Seeds that germinated on the 14th day or during a subsequent 7-day incubation in a gibberellin solution were classified as HD seeds. Molecular markers were run on both HD and LD individuals and resistance frequencies were determined. In the greenhouse study, stratified and non-stratified seeds were planted and resulting plants were sprayed to determine resistance frequencies. Seeds germinating without stratification were considered to be LD seeds. Our study found that resistance to ALS inhibitors was linked to seed dormancy, with a higher percentage of resistance to ALS inhibitors observed in HD seeds than in LD seeds. In contrast, resistance to PPO inhibitors was not consistently linked to seed dormancy.

ECOLOGICAL FITNESS OF GLYPHOSATE RESISTANT KOCHIA (*KOCHIA SCOPARIA)*. O. Adewale Osipitan*[1], J. Anita Dille[1], Phillip W. Stahlman[2], David C. Hartnett[3], Allan K. Fritz[1]; [1]Agronomy Department, Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS, [3]Biological Sciences, Kansas State University, Manhattan, KS (73)

The development and dissemination of herbicide-resistant weeds pose a significant threat to modern agriculture. Mechanism for glyphosate resistance in kochia is suspected to be gene amplification of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). Ecological fitness is important in describing the evolutionary advantage of a biotype. It is based on its survivorship, fecundity and competitiveness. Multiple herbicide resistance could alter the expected fitness of a given population. Thus a preliminary greenhouse study evaluated the single and multiple resistance of six kochia populations from Kansas to glyphosate, atrazine, chlorsulfuron, and dicamba. Scott, Finney, and Thomas county populations were resistant to glyphosate while Phillips, Wallace and Wichita county populations were susceptible to glyphosate. A field study was conducted in summer 2014 to evaluate the ecological fitness of these kochia populations. The experiment was laid out in a randomized complete block design with 10 replications. One individual target plant was surrounded by one of three densities of neighbor plants: equivalent to 12, 35, or 70 plants m-2. Results showed that populations from Scott and Thomas counties appear to have greater glyphosate resistance than from Finney county. The three glyphosate-resistant populations were also resistant to dicamba and chlorsulfuron. About 83% of Finney population survived atrazine while none of Scott and Thomas populations survived atrazine at normal field rate (2240 g ai ha-1). Kochia plant height across populations varied with days after planting. Scott (a glyphosate-resistant population) was the tallest while Thomas (also a glyphosate-resistant population) was the shortest. By the end of the season, plant heights of kochia populations at each level of neighbor density were not different. Plant height of individual populations decreased with increasing neighbor density. Plant height performance at increasing stages of growth did not separate glyphosate-resistant from -susceptible populations. There was no difference between the resistant and susceptible populations in respect to stem diameter at physiological maturity and days to first flowering. There was a lot of variability among the six populations that differences are difficult to determine.

EFFECT OF HERBICIDES ON RECOVERY AND PATHOGENICITY OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS*, CAUSAL AGENT OF GOSS'S WILT OF CORN. Joseph T. Ikley*[1], Kiersten A. Wise[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (74)

Goss's bacterial wilt and leaf blight of corn is caused by the bacterium *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). This disease reemerged as an important disease in the corn belt in the mid-2000's and has recently become more widespread with confirmed cases in 17 states in the Midwest. Planting hybrids that have genetic resistance to the disease, along with tillage and rotating to a non-host crop are currently the recommended management strategies since there are no effective chemical management options. Some grass weed species and cover crops have been documented as additional hosts of Cmn, therefore controlling these hosts could reduce inoculum levels in a field. The objectives of this experiment were to apply single active ingredient herbicides to Cmn-infected weeds to determine if pathogenic Cmn could be recovered from plants after treatment. In the greenhouse, three confirmed hosts were inoculated with a bacterial suspension containing 1 x 10^8 colony-forming units (CFU) of Cmn per ml. Two weeks after inoculation, disease severity was visually estimated to confirm successful inoculation. Inoculated plants were arranged in a randomized complete block design with five replicates. Treatments consisted of seven herbicides and an untreated control. Two weeks after herbicide application, percent weed control was visually estimated. Leaf tissue from all plants were examined for bacterial streaming and plated onto Cmn-selective medium. Recovered bacteria were then used to inoculate a susceptible corn hybrid to test pathogenicity. Results from three experimental runs show that, despite varying control levels ranging from no injury to complete plant death, herbicide treatment did not reduce pathogenicity of bacteria recovered from infected weed species. This study reinforces the importance of using preemergence weed control programs in fields with a history of Goss's wilt since debris from Cmn-infected weeds that are treated with postemergence herbicides can contain pathogenic bacteria and can serve as an additional source of inoculum in corn.

N_2O EMISSIONS FROM SOYBEAN AS INFLUENCED BY HERBICIDE MANAGEMENT STRATEGY AND ROW WIDTH. Rebecca R. Bailey*, Thomas R. Butts, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (75)

Nitrous oxide (N_2O) is a harmful greenhouse gas produced when there is high soil moisture and increased concentrations of soil nitrate (NO_3^-). Management practices that alter the availability water and NO_3^- in the soil, therefore, can directly influence N_2O emissions. This research evaluates the impact of weed management and row width on N_2O emissions in soybean. In the absence of preemergence (PRE) herbicides, weeds compete with soybean for available soil moisture and NO_3^-, and may reduce N_2O emissions relative to a weed-free environment. However, after weeds are killed with a postemergence (POST) herbicide, the dead weed residues remaining on the soil surface act as a carbon and nitrogen source which may stimulate N_2O emissions. Soybean row width is known to influence weed growth and biomass accumulation, with wider rows often resulting in more weed biomass. As a result, row width may further impact soil water and nitrate availability, and ultimately, N_2O emissions. A study was conducted in 2013 and 2014 at Arlington Agricultural Research Station near Arlington, WI (43.30 N, 89.32 W). A 2x2 factorial treatment structure of weed management (PRE + POST vs. POST-only) and row width (38- or 76-cm) was arranged in a RCBD with four replications. On May 14, 2013 and May 22, 2014 soybean was planted at a target population of 322, 000 seeds ha^{-1}, and PRE herbicides were applied within a day of planting. In 2013, POST applications were made 50 days after planting (DAP) if following a PRE and 31 DAP for POST-only treatments, while in 2014 all POST applications were made 42 DAP. N_2O emissions were measured from static gas sampling chambers placed within each plot. Samples were collected at least weekly starting 14 DAP until mid-September. Since different years and treatments had varying POST application timings, emissions data before termination were normalized to a 28 day span while emissions after termination were normalized to an 81 day span. Data were compared using a mixed model procedure in SAS 9.3 with *weed*, *width*, and *weed*width* treated as fixed effects and *year* and *rep(year)* as random. Means were separated with Fischer's Protected LSD at α = 0.05. Yield data were also compared using the same mixed model procedure. POST-only treatments had lower N_2O emissions than PRE + POST treatments before termination, but otherwise there was no significant effect of *weed*, *width*, or *weed*width* on N_2O emissions either before termination, after termination, or for the full study at α = 0.05. Soybean yield was not influenced by *width* or *weed*width* (p=0.6018 and p=0.5825, respectively), but yield for PRE + POST treatments (4270 kg ha^{-1}) was significantly higher than yield for POST-only treatments (3620 kg ha^{-1}) (p=0.0007). These results indicate that while weed management strategy may not be an effective means to mitigate season-long N_2O emissions from soybean, use of a PRE herbicide is still recommended to increase soybean yield.

RATE AND DURATION OF EMERGENCE IN RESPONSE TO TILLAGE AND COMPETITION EFFECTS IN 2,4-D RESISTANT COMMON WATERHEMP (*AMARANTHUS TUBERCULATUS*). Lacy J. Leibhart*[1], Lowell D. Sandell[1], Zac J. Reicher[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (76)

Common waterhemp often eludes control in part due to its extended germination period. A population of common waterhemp examined in both the field and greenhouse was confirmed resistant to 2,4-D in 2011, further limiting control options and increasing the demand for adequate timing of control methods. Quantifying the rate and duration of its emergence provides data for producers to make timely mechanical and/or chemical applications to control this and potential future resistant populations of waterhemp. To examine the effect of tillage and competition on common waterhemp emergence, treatments included three tillage timings, a no-till without competition, and a no-till with intraspecies competition. However, no treatment effect existed in any of the three years of the experiment. Furthermore, emergence is heavily impacted by precipitation, with 95% and 71%, respectively, of emergence occurring prior to June because of the early spring rains of May in 2012 and 2013. In contrast, in 2014 precipitation continued into June with 54% of common waterhemp emergence occurring in June because of the dryer conditions. In conclusion, emergence is more affected by precipitation than tillage or competition effects. Control methods should be applied immediately following spring rains based on the results of this study.

RESPONSE OF VELVETLEAF POPULATIONS FROM SOUTH-WESTERN NEBRASKA TO GLYPHOSATE. Bruno Canella Vieira*[1], Spencer L. Sameulson[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (77)

Velvetleaf (*Abutilon theophrasti* Medik), member of Malvaceae family, is considered an important annual weed in soybean and corn crops in the US due to its rapid growth habit, a robust seedling vigor and a very competitive behavior. Furthermore, velvetleaf has been thought to be relatively tolerant to herbicides, resulting in a concerning situation among growers. The intense use of glyphosate worldwide has dramatically increased velvetleaf to exposure of glyphosate, resulting in a high selection pressure for the evolution of glyphosate-tolerant and -resistant velvetleaf populations. Populations from 31 different weed species have been reported as glyphosate-resistant but to this point velvetleaf has not been one of them. The objective of this study was to investigate the response of velvetleaf populations from south-western Nebraska to glyphosate. A total of 20 velvetleaf populations were collected among south-western Nebraska and were subjected to a glyphosate dose response study. When plants were 10 cm tall, they were sprayed with one of the following rates of glyphosate: 0, 217, 434, 868, 1736, 3472 and 6946 g ae ha^{-1}. Visual injury estimations (0-100%) were measured 28 days after treatment (DAT) and data were analyzed using a non-linear regression model with drc package in R 3.1.2. I_{50} values were estimated using a four parameter log logistic equation: $y = c + (d - c / 1 + \exp(b(\log x - \log e)))$. Resistance ratios were calculated by dividing the I_{50} of each population by the I_{50} value of the most sensitive population. The study results indicated a 6.7 fold difference in the I_{50} resistance ratio between the most and the least sensitive populations. The most sensitive population had an I_{50} of 528 g ae ha^{-1}. The least sensitive population had an I_{50} of 3511 g ae ha^{-1}. The study results suggest that there is significant variability in the response of velvetleaf to glyphosate among Nebraska populations. Thus, appropriate integrated weed management (IWM) strategies are a key factor for the successful management of velvetleaf.

FREQUENCY OF ATRAZINE RESISTANCE IN KOCHIA POPULATIONS FROM SOUTH-WESTERN NEBRASKA. Spencer L. Sameulson*[1], Bruno Canella Vieira[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (78)

Kochia (*Kochia scoparia (L.) Schrad.*) has been reported as having resistance to glyphosate as well as other herbicide mode of actions. In south-western Nebraska, kochia has become very problematic for growers to manage, and in corn, atrazine is a very valuable tool for managment. The objective of this study was to evaluate distribution and frequency of atrazine resistance in kochia throughout south-western Nebraska. Collections of kochia populations were made by traveling 17 south-western counties of the state and collecting up to 20 plants from fields that had kochia escapes. Greater emphasis was made in finding fields that had large populations that were not just along the edge of the field or road sides, but that were in the middle of the field with the crop. At the time the population was collected, the GPS coordinates and in-field agronomic practices were recorded. Mature plants were harvested and seeds were separated from the plant and stored at 0 C until the commencement of the greenhouse testing. Seeds were germinated in the greenhouse and treated with atrazine at 2180 g ha^{-1} when plants were 10-15 cm tall. Visual estimates of injury were collected on a scale of 0-100 (0 being no effect from herbicide and 100 being complete control). Visual estimates of injury were recorded at 28 days after treatment (DAT). Surviving plants were harvested and weighed to determine fresh and dry weight biomass accumulation. Data were calculated for mean and standard error to determine mean level of visual estimates of injury. Resistance was observed in 4 populations in Chase, Furnas, Gosper, and Kearney counties. There were 25 populations that had less than 100% control that showed some level of tolerance to atrazine. There were 42% of the 50 populations tested that had 100% control across all replications which is what is expected from susceptible plants. Further sampling and treatment is being held to discover additional atrazine resistant populations of kochia. This survey is helpful in mapping the location of atrazine-resistant populations in south-western Nebraska.

FACTORS AFFECTING THE GERMINATION AND EMERGENCE OF GLYPHOSATE-RESISTANT HYBRID AND VOLUNTEER CORN (*ZEA MAYS* L.). Parminder S. Chahal*[1], Greg R. Kruger[2], Humberto Blanco-Canqui[3], Amit J. Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE, [3]Assistant Professor, Lincoln, NE (79)

Glyphosate-resistant volunteer corn is a problematic weed in corn-soybean cropping systems, specifically in the Midwestern United States. Scientific literature is not available about the factors affecting germination and emergence of glyphosate-resistant volunteer corn. Laboratory and greenhouse experiments were conducted in 2012 and 2013 to determine the effects of alternating day/night temperature, light, osmotic stress, salt stress, pH, seed burial depth, and flooding duration on the germination and emergence of glyphosate-resistant hybrid and volunteer corn. Germination was affected by various agronomic and environmental factors; however, the response of hybrid and volunteer corn was similar to majority of the variables tested. Optimum germination (84 to 97%) was observed at the day/night temperature of 15/10 C to 42.5/30 C, while higher temperature (45/35 C) reduced the germination to < 6%. The alternating light and dark periods had no effect on the germination of hybrid and volunteer corn, while it was reduced significantly (< 65%) with increasing the osmotic stress (0.4 to 1.3 MPa) with optimum germination (> 90%) at 0 to 0.3 MPa. Germination (> 90%) was observed at a wide range of salt concentrations (0 to 160 Mm) with lowest germination (53%) at 320 mM. Highest hybrid corn germination was favored by neutral to mild alkaline pH, while acidic pH favored volunteer corn germination. The seedling emergence of hybrid and volunteer corn occurred over a wide range of seed burial depth (0- to 15-cm), with optimum emergence at 0.5- to 6-cm depth. Hybrid corn seedling emergence reduced from 86 to 23% at 1 and 2 d of flooding duration, while volunteer corn emergence was 21% at 1 and 2 d of flooding. Hybrid and volunteer corn were equally sensitive to the flooding duration of 4 or more than 4 d, with < 5% emergence at 4 d of flooding with no emergence beyond 4 d of flooding. Results of this study suggest that volunteer corn can germinate and emerge in a wide range of climatic conditions, ensuring its continued presence in the Midwest.

SCREENING FOR RESISTANCE TO 20X RATES OF GLYPHOSATE IN BIOTYPES OF *CONYZA CANADENSIS* FROM SOYBEAN FIELDS AND NON-AGRICULTURAL HABITATS IN OHIO AND IOWA. Zachery T. Beres*[1], Emily E. Ernst[1], Allison A. Snow[1], Jason T. Parrish[1], Micheal D. Owen[2], Bruce A. Ackley[1], Mark M. Loux[1]; [1]Ohio State University, Columbus, OH, [2]Iowa State University, Ames, IA (80)

Glyphosate is the leading herbicide throughout the world and is widely used with glyphosate-tolerant crops, but its efficacy has been compromised where weed species have evolved resistance. To better understand evolutionary outcomes of continued, strong selection from glyphosate exposure, we screened for variation in levels of resistance in Conyza canadensis (horseweed), a highly self-pollinating weed. We hypothesized that levels of glyphosate resistance would be greater in Ohio, where resistance in Conyza canadensis was first reported in 2003, compared to Iowa, where it was first reported in 2012. Within each state, we compared individual biotypes (maternal seed families) that had survived in no-till soybean fields vs. those found in non-agricultural sites such as abandoned fields and roadsides. In 2013, we collected seeds from one maternal plant in each of 88 populations in Ohio and 28 populations in Iowa. Populations were sampled from 6 counties in Ohio (3 southwest, 3 northeast) and 20 counties in Iowa, but we did not attempt to use systematic, random sampling methods. To evaluate resistance, we screened rosettes from each biotype at each of three dosages: 1X (= 0.84 kg ae glyphosate/ha), 8X, and 20X, along with 0X controls. For ease of presentation, biotypes with at least 80% survival at each dosage were designated as either “resistant” (1X), “highly resistant” (8X), or “extremely resistant” (20X), respectively. Frequencies and spatial patterns of survival and damage at 1X, 8X, and 20X will be reported. Pooling data for both states, most of the biotypes from soybean fields were resistant at 1X or higher. We found that 40% and 36% of the biotypes from soybean fields were extremely resistant in Ohio and Iowa, respectively. For non-agricultural sites, 38% of the Ohio biotypes also were extremely resistant, while none of those from Iowa had such a high level of resistance and 93% of these Iowa biotypes were susceptible at 1X. Although our sampling strategy was not comprehensive, these results suggest that maternal families with resistance to 20X glyphosate occur in Ohio and Iowa, and that non-agricultural habitats in Ohio often support resistant plants. Possible reasons for finding relatively more resistant biotypes overall in sampled populations from Ohio, as compared to Iowa, could include earlier and more widespread selection pressures, stronger herbicide dosages used for weed management, and differences in the extent of seed-mediated gene flow from agricultural to non-agricultural habitats.

INFLUENCE OF SPRING TILLAGE ON COMMON RAGWEED EMERGENCE IN NEBRASKA. Ethann R. Barnes*[1], Rodrigo Werle[1], Lowell D. Sandell[2], Amit J. Jhala[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Valent USA Corporation, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (81)

Common ragweed (*Ambrosia artemisiifolia* L.) is a competitive species in soybean production fields. Glyphosate-resistant common ragweed has been recently confirmed in Nebraska. Common ragweed emergence is typically early in the season. Tillage before planting is being considered as an additional tool to control glyphosate-resistant common ragweed; however, the effect of tillage on common ragweed emergence pattern is unknown. The objective of this study was to evaluate the influence of spring tillage on the emergence pattern of a glyphosate resistant common ragweed biotype from Nebraska. A field experiment was conducted in 2014 near Adams, NE, where glyphosate-resistant common ragweed was confirmed. Tillage was simulated with a 50 cm wide rototiller, operated at a depth of 10 cm. There were three different tillage treatments throughout the emergence period. The first tillage timing was May 7, after initial emergence was observed within the study. The second and third tillage

timings were May 21 and June 12, respectively. The fourth treatment was designed as a control, where plots were left not tilled. The field experiment was arranged in a randomized complete block design. Starting in April, on a weekly basis, common ragweed seedlings were counted and pulled from three 0.3 m by 0.3 m quadrats placed within each block spaced 1.2 m apart. Tillage had neither effect on total emergence (P=0.493) nor on time to 50% emergence (P=0.081). On average, 3,196 seedlings m^{-2} emerged and by May 4, 50% emergence was completed. Most of the common ragweed seedlings emerged before soybean planting time, making spring tillage an alternative management option to control glyphosate-resistant common ragweed in this region. This study will be repeated in 2015.

GIANT RAGWEED SEED PRODUCTION AND RETENTION IN SOYBEAN AND FIELD MARGINS. Jared J. Goplen*[1], Jeffrey L. Gunsolus[2], Craig C. Sheaffer[2], Roger L. Becker[2], Jeffrey A. Coulter[2], Fritz Breitenbach[2], Lisa Behnken[2], Gregg A. Johnson[2]; [1]University of Minnesota, Saint Paul, MN, [2]University of Minnesota, St. Paul, MN (82)

Biotypes of giant ragweed (*Ambrosia trifida*) resistant to multiple herbicide sites of action have been identified in Minnesota. Biotypes resistant to multiple herbicides reduce the number of effective herbicides for a given crop and necessitates the development of alternative weed control strategies, including nonchemical approaches. Seed-destruction equipment limiting the amount of weed seed reentering the weed seed bank at harvest can be an effective control strategy against herbicide-resistant weed species that retain their seed until crop harvest. Therefore, a better understanding of giant ragweed phenology is necessary to determine the applicability of seed destruction technologies for giant ragweed control. Seed retention of giant ragweed was monitored from 2012-2014 in Minnesota to determine the pattern of giant ragweed seed rain. Seed collection traps (0.9m diameter) were constructed and placed around individual giant ragweed plants growing in soybean and adjacent field margins to collect seed at weekly intervals. Collected seed was counted each week and categorized as being hard (potentially viable) and soft (non-viable) based on a probe pressure test. Giant ragweed plants produced an average of 1796 ± 413 seeds per plant with 64% ± 4% being potentially viable in 2012 and 1115 ± 414 seeds per plant with 77% ± 3% being potentially viable in 2013. In all years, giant ragweed began dropping seed the first week of September and continued through October. The seed tended to remain on the plant well into the fall, with an average of 63% of the potentially viable seed remaining on the plant at the end of October in 2012 and 2013, which is well after the typical harvest date for soybean. Data from 2014 is currently being analyzed but preliminary results suggest it follows a similar pattern as 2012 and 2013. These results suggest that alternative weed management practices that capture or destroy giant ragweed seed at crop harvest have potential for being used in an herbicide-resistant giant ragweed management strategy, by limiting replenishment of the seed-bank.

IDENTIFICATION AND DETERMINATION OF GLYPHOSATE-RESISTANT *AMARANTHUS* SPP. USING MOLECULAR MARKERS. Brittany Janney*, Rong Ma, Kris N. Lambert, Dean E. Riechers; University of Illinois, Urbana, IL (83)

Herbicides containing glyphosate are commonly used for weed control in glyphosate-resistant corn, soybean, and cotton. However, several species and populations in the genus *Amaranthus* are now glyphosate resistant. Our objectives were to (1) determine if an unknown *Amaranthus* seedling is glyphosate resistant, and (2) identify the species of *Amaranthus* while still in the young seedling stage. Total RNA of young leaf samples from an unknown seedling were extracted using an RNA extraction kit, and were converted into cDNA using reverse transcriptase (RT). A semi-quantitative RT-PCR assay was conducted to determine if the species is glyphosate resistant due to an over expression of *EPSPs*. Our assay detected elevated expression of *EPSPs* in plants from a known glyphosate-resistant Palmer amaranth (*Amaranthus palmeri)* population, which had 45 copies of *EPSPs*. Species-specific markers using *Acu*I and *Bci*VI restriction enzymes were then developed by digestion of *EPSPs* RT-PCR products, which were gel purified from the previous assay, to identify the *Amaranthus* species. A restriction fragment length polymorphism (RFLP) in the RT-PCR product following *Acu*I digestion determined that the plant is waterhemp (*A. tuberculatus)*. An RFLP in the RT-PCR product following *Bci*VI digestion determined that the plant is *A. palmeri.* Spiny amaranth (*A. spinosus)* can be easily identified by its spines located along its stem. In combination with this phenotypic marker, our RT-PCR based assay can identify from among three unknown *Amaranthus* species and determine if the unknown seedling is glyphosate resistant due to increased *EPSPs* expression. This rapid and cost-efficient method of identifying and determining unknown glyphosate-resistant *Amaranthus* seedlings will be valuable for farmers and weed scientists for determining the most effective management strategies for these hard-to-control species while still in the critical early seedling stage.

TERMINATION STRATEGIES FOR WINTER RYE AND OVERWINTERING ANNUAL RYEGRASS WITH GLYPHOSATE. Daniel H. Smith*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (84)

Midwest corn and soybean producers have an increasing interest in an annual ryegrass and winter rye cover crops in the North Central region due to the benefits of reducing soil erosion, scavenging nutrients, and increasing soil organic matter. Annual ryegrass may or may not survive winter in the Upper North Central region depending upon variety and winter conditions like temperature and the duration of snow cover. This study was conducted to compare glyphosate application rates for winter rye and annual ryegrass at three different timings. Annual ryegrass and winter rye plots were established at Arlington Agricultural Research Station, Arlington, WI on September 9, 2013. The winter rye variety was ‘Guardian’. The annual ryegrass varieties included ‘Bruiser’, ‘King’, and ‘Gulf’. In the spring of 2014, herbicides were applied at three different timings each with four different glyphosate rates. Timings included early- May, mid-May, and early-June. Glyphosate rates include 0, 0.62, 1.26, 2.52, and 5.04 kg ae ha^{-1}. Treatments were replicated four times. Fourteen days after application, the cover crop termination was assessed by collecting digital images which were analyzed for percent green cover by SigmaScan® Pro software utilizing the Turf Analysis 1-2 Macro and additionally by harvesting biomass from a $0.25m^2$ quadrat and comparing the production of dry biomass. Percent green cover of annual ryegrass and winter rye decreased ($P<0.0001$) for all cover crops at all rates at 14 days after application. Annual ryegrass and winter rye dry biomass weight was significantly decreased ($P<0.0001$) at the 0.62 kg ae ha^{-1} glyphosate rate for early May and June applications. More research will be needed to establish best management practices for farmers interested in the use of glyphosate as a primary termination method.

COMMON AND TARTARY BUCKWHEAT AS SUMMER COVER CROPS FOR WEED SUPPRESSION IN VEGETABLE CROPPING SYSTEMS. Mary T. Saunders Bulan, David E. Stoltenberg*, Joshua L. Posner; University of Wisconsin-Madison, Madison, WI (85)

Common buckwheat (*Fagopyrum esculentum* Moench) is a broadleaved annual species that is valued as a summer cover crop because of its quick growth, weed suppressive ability, and ease of management. Tartary buckwheat [*F. tataricum* (L.) Gaertn.] is a related species that has been reported to grow more vigorously than common buckwheat, especially in cool environments, potentially providing greater weed suppression in vegetable cropping systems in northern, temperate climates. Our research objective was to determine the effectiveness of tartary buckwheat relative to common buckwheat for weed suppression both during the cover-cropping phase and after cover crop termination in no-tillage (roller-crimping and sickle-bar mowing) and conventional-tillage cabbage production systems. Across three site-years, we found that common buckwheat emerged earlier and produced 64% more shoot biomass than tartary buckwheat. Before cover crop termination, weed shoot biomass (predominantly *Amaranthus* and *Setaria* spp.) was 3- to 5-fold greater in tartary buckwheat than in common buckwheat treatments, and did not differ from weed shoot biomass in a control fallow treatment, in two of three site-years. In contrast, weed shoot biomass in common buckwheat was less than in the fallow control treatment across all site-years. After cover crop termination, weed shoot biomass in all treatments increased with thermal time, but the rate of increase and late-season total shoot biomass did not differ between cover crops. Similarly, cabbage yield did not differ between cover crops, but late-season weed biomass was greater, and cabbage yield was less, in no-tillage than conventional-tillage treatments. These results suggest that tartary buckwheat is not a superior alternative to common buckwheat as a summer cover crop for weed suppression in vegetable production systems.

IMPACT OF APPLICATIONS OF DICAMBA AND DICAMBA PLUS GLYPHOSATE USING AIR-INDUCTION NOZZLES ON GLYPHOSATE-RESISTANT KOCHIA. Cody F. Creech*[1], William E. Bagley[2], Ryan S. Henry[1], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (86)

The development of growth regulator soybean traits will allow soybean growers the opportunity of using a growth regulator to control broadleaf weeds in-season. Growth regulators have long been associated with injury associated with off-target movement of herbicides. In an effort to mitigate off-target movement, applications of growth regulators in soybean will be made using air-induction nozzles that produce large droplets. This field study was conducted to evaluate the use of such nozzles on the efficacy of dicamba formulations with and without the use of a drift reducing adjuvant. Dicamba (0.14 kg ae ha^{-1}; Clarity), and dicamba plus glyphosate (1.18 kg ae ha^{-1}; Roundup PowerMax) were applied either alone or with a drift reduction adjuvant (invert emulsion consisting mainly of modified vegetable oil and aliphatic mineral oil; In-place). Four air-induction nozzles (AIXR11004, ULD12004, TDXL-D11004 and TTI11004) were used to apply the treatments at 140 L ha^{-1}. Applications were made using an ATV sprayer with a 3 m boom at 276 kPa and 8 kph. The plots were 16 m long and were replicated 4 times. Treatments were applied to kochia (*Kochia scoparia*) and Russian thistle (*Salsola tragus*) near Big Springs, NE that were actively growing in wheat stubble. Visual estimations of weed control were collected at 7, 14, 21 and 28 days after treatment. Data were subjected to ANOVA using repeated measures with replication as the random variable. The effect of the air-induction nozzles was not significant indicating that performance was not different across the four nozzles tested in this study. There was a significant spray solution by species interactions. The applications of dicamba plus glyphosate had the weed control for both species. The drift control adjuvant did not reduce the efficacy of the applications. Drift reduction technology available through air-induction nozzles and appropriate adjuvants should be used when applying dicamba to limit off-target movement.

HERBICIDE EFFICACY ON GLYPHOSATE RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*) AND COMMON WATERHEMP (*AMARANTHUS RUDIS*) AS INFLUENCED BY SPRAY NOZZLE DESIGN. Travis R. Legleiter*[1], William G. Johnson[2], Bryan Young[3]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN, [3]Purdue University, W. Lafayette, IN (87)

Broadcast spray nozzles that contain pre-orifice, turbulence chamber, venturi air induction, or a combination of designs are recommended for low-drift applications of systemic herbicides. Experiments were conducted at three Indiana locations during 2014 evaluating the influence of the nozzle designs on efficacy of 280 g ae ha^{-1} glyphosate plus 280 g ha^{-1} 2,4-D applied in soybean on two glyphosate-resistant weeds: Palmer amaranth and common waterhemp. Spraying System

Co. TeeJet brand Turbo TeeJet, Air Induction Extended Range, and Turbo TeeJet Induction nozzles representing the low drift nozzle designs as well as an Extended Range flat fan nozzle were evaluated for effects on herbicide efficacy. Applications were made to 10 to 20 cm Palmer amaranth and common waterhemp in soybean plots with an ATV sprayer equipped with 11004 nozzles traveling at 19 km hr^{-1}. Herbicide efficacy was evaluated by taking plant heights and biomass in comparison to an untreated check at 21 days after treatment. Plant heights were reduced by 40 to 60%, while biomass was reduced by 70 to 90% regardless of location or glyphosate-resistant weed species. Nozzle designs did not have an influence on differences in height and biomass reduction for either of glyphosate-resistant Palmer amaranth or common waterhemp. Results from this study reinforce the utility of nozzles containing pre-orifice, turbulence chamber, and air induction designs for effective postemergence applications of 2,4-D plus glyphosate.

LINKING DROPLET SIZE AND DEPOSITION FROM COARSE NOZZLES IN A WIND TUNNEL. J Connor Ferguson*[1], Chris C. O'Donnell[1], Greg R. Kruger[2], Andrew J. Hewitt[1]; [1]The University of Queensland, Gatton, Australia, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (88)

A study to connect the droplet size and deposition of Coarse droplet producing nozzles was conducted at the University of Queensland Gatton Wind Tunnel Research Facility. The droplet size spectra of 21 Coarse droplet producing nozzles were compared with three solutions: water only, pinoxaden at 0.2% v/v + cloquintocet-mexyl at 5 g ha^{-1} and a methylated seed oil at 0.5% v/v (Axial + Adigor, Syngenta Australia Pty Limited, Macquarie Park, NSW, Australia), and clopyralid at 0.25% v/v (Lontrel Advanced, Dow AgroSciences Australia Limited, Frenches Forest, NSW, Australia). Droplet size spectra were measured using a Sympatec Helos laser diffraction instrument (Sympatec Inc., Clausthal, Germany). Twelve of those nozzles were further compared against a standard flat-fan nozzle in a wind tunnel deposition study with water + a visible dye to examine droplet deposition on Kromekote cards. Deposition was measured at two wind speeds, 2.2 m/s and 4.4 m/s against the wind direction. The single-nozzle track sprayer was traversed 4 m at 2.2 m/s, which is a common driving speed for ground boom sprayers in Australia. The cards were arranged to mimic a wheat plant, a canola plant, or placed on the ground for ground deposition. The cards were analyzed for percent coverage by using Image J software and percentages were compared to theoretical deposition based on their droplet sizes from the previous study. The results showed variability among deposition percentages of the Coarse droplet producing nozzles even with a similar droplet size spectrum. This work will further improve the selection of technologies to select those with greater deposition for improved efficacy.

IMPACT OF APPLICATIONS OF DICAMBA AND DICAMBA PLUS GLYPHOSATE USING AIR-INDUCTION NOZZLES ON GLYPHOSATE-RESISTANT WATERHEMP. Rafael Pieroni Catojo*[1], Cody F. Creech[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (89)

Managing broadleaf weeds postemergence in soybean can be challenging at times. Use of growth regulator herbicides coupled with the impending herbicide-tolerant traits will provide another option for helping improve postemergence weed control of broadleaf weeds in soybean. Applications of growth regulators in soybean using venturi nozzles that produce large droplets will be made to try to avoid off-target movement however, there is some concern that the droplet size could potentially get too large to maintain efficacy at a high level introducing selection pressure for resistance or potential weed control failures in some fields. The objective of this study was to evaluate different combinations of dicamba and dicamba plus glyphosate both with and without the use of a drift reducing adjuvant using those venturi nozzles in the field under common application conditions. Dicamba (0.14 kg ae ha^{-1}) and dicamba (0.14 kg ae ha^{-1}) plus glyphosate (1.18 kg ae ha^{-1}) were applied either alone or with a drift reduction adjuvant (invert emulsion consisting mainly of modified vegetable oil and aliphatic mineral oil). Four venturi nozzles (AIXR11004, ULD12004, TDXL-D11004 and TTI11004) were used to apply the treatments at 140 l ha^{-1}. Applications were made using ATV sprayer with a 3 m boom at 276 kPa and 8 kph. The plots were 16 m long and were replicated four times. Treatments were applied to glyphosate-resistant commom waterhemp (*Amaranthus rudis*) near Fremont, NE. Visual estimations of control were collected at 7, 14, 21 and 28 days after treatment using a scale of 0 – 100 where 0 = no control and 100 = total control. Data were analyzed using repeated measures separately for each site. The combinations of dicamba plus glyphosate had greater efficacy on the control of waterhemp than applications using only dicamba alone despite having a population that was glyphosate resistant. There was no difference between the nozzles tested in this study. There was an effect on the efficacy of the herbicides when using a drift reduction adjuvant. The use of invert emulsion drift reduction adjuvants can help manage drift without causing a reduction in efficacy based on this study and should be considered for applications to limit off-target movement.

THE INFLUENCE OF NOZZLE TYPE ON THE PERFORMANCE OF PPO HERBICIDES FOR POST SOYBEAN APPLICATIONS. Camila de Carvalho Ozorio*[1], Cody F. Creech[1], Ryan S. Henry[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (90)

The performance of herbicides can be affected by numerous factors including nozzle selection. Postemergence (POST) applications in soybean are limited to a few herbicide mode of actions, and the establishment of glyphosate-tolerant weed species has forced some growers to expand their herbicide use patterns to include more of those limited options. Several protoporphyrinogen oxidase (PPO)-inhibiting herbicides are labeled for POST applications in soybean, although the application requirements for these herbicides may limit their adoption or correct deployment. The application rates are often balanced with ensuring acceptable efficacy and limited soybean injury, and this can cause reduced weed control. Confounding this issue, the label language for many PPO-inhibiting herbicides is ambiguous or conflicting in regards to the application strategy. For example, the label may state that thorough coverage of the weed specie(s) is required for adequate control, but the spray quality should be coarse or coarser to reduce off-target movement. The objective of this experiment was to evaluate the performance of several nozzle types, producing a range of spray qualities, when using PPO-inhibiting herbicides for POST soybean applications. This study was completed at the PAT Lab in North Platte, NE utilizing a spray chamber and greenhouse. Four weed species were applied with three different PPO-inhibiting herbicides (lactofen, flumiclora pentyl ester, and carfentrazone-ethyl) using five nozzles (TeeJet XR, TT, TTJ, AIXR, and TTI) at 276 kPa and at 4.8 kph. At one week after application, the XR and TTJ nozzles resulted in the highest injury, even though the spray qualities ranged from fine to coarse for these treatments. At four weeks after application, spray quality did not have an impact on visual estimations of injury. This data will be beneficial to applicators to maximize weed control when applying PPO-inhibiting herbicides.

EFFICACY OF DICAMBA AND DICAMBA PLUS GLYPHOSATE APPLICATIONS WITH AND WITHOUT DRIFT CONTROL ADJUVANTS THROUGH FOUR VENTURI-TYPE NOZZLES. Leon Cimo*[1], Cody F. Creech[1], Ryan S. Henry[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (91)

Adjuvants are known to modify spray quality and efficacy of herbicide applications and can perform differently when used with different nozzle types. Dicamba applications can cause significant injury to sensitive neighboring areas due to off-target movement. The use of venturi-type nozzles and drift control adjuvants (DCA) has been shown to reduce the propensity for dicamba applications to move off-target. However, concern exists that the efficacy of dicamba could be negatively impacted when using drift reduction technologies (DRT). The objective of this study was to evaluate dicamba efficacy when applied alone or with glyphosate with or without a DCA when applied through four venturi-type nozzles. The treatments were applied using two rates. Dicamba (0.07 and 0.14 kg ae ha^{-1}) alone and in combination with glyphosate (0.59 and 1.18 kg ae ha^{-1}) was applied with and without a DCA (0.29 L ha^{-1}). These chemical combinations were sprayed using four 1.82 L min^{-1} air-induction nozzles (AIXR, ULD, TDXL-D and TTI). Herbicide, adjuvant, and nozzle combinations were applied to five plant species: common waterhemp (*Amaranthus rudis*), common lambsquarters (*Chenopodium album*), velvetleaf (*Abutilon theophrasti*) and grain amaranth (*Amaranthus hypochondriacus*). Plants were grown inside a greenhouse located at the Pesticide Application Technology Laboratory, West Central Research and Extension Center, University of Nebraska-Lincoln in North Platte, NE. Applications were made using a single nozzle track sprayer. Visual estimations of injury were collected at 7, 14, 21, and 28 days after treatment (DAT) using a scale of 0 – 100 where 0 = no injury and 100 = plant death. At 28 DAT, plants were clipped at the soil surface and wet weights were recorded. These samples were then dried until constant weight and those were recorded. The addition of DRA to dicamba plus glyphosate performed better than the other spray mixtures for all species. The ULD and TDXL-D had greater injury ratings for all species except lambsquarters which the ULD was only better than the TTI nozzle. The addition of glyphosate to dicamba increased the injury for all species. The use of a DRA with dicamba spray solutions can decrease the risk of off-target movement and can increase the efficacy of the application in some instances. Applicators should use a nozzle type that provides adequate drift protection for the environmental conditions expected during application and does not negatively impact the efficacy of the application.

DROPLET RETENTION ON SOYBEAN LEAVES AS INFLULENCED BY NOZZLE TYPE, APPLICATION PRESSURE, AND ADJUVANT. Maximila Miranda Martins*[1], Cody F. Creech[1], Ryan S. Henry[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (92)

Off-target movement of growth regulator herbicides can cause severe injury to susceptible plants. Apart from not spraying on windy days or using excessively high boom heights, making herbicide applications using nozzles that produce large droplets is the preferred method to reducing herbicide drift. Although large droplets maintain a higher velocity and are more likely to reach the leaf surface in windy conditions, their ability to remain on the leaf surface is not well understood. Upon impaction with the leaf surface, droplets may shatter, bounce, roll off, or be retained on a leaf surface. This study was conducted to evaluate nozzle, adjuvant and pressure on spray retention of a leaf surface. Soybean plants were grown inside a greenhouse located at the Pesticide Application Technology Laboratory, West Central Research and Extension Center, University of Nebraska-Lincoln in North Platte, NE. Plants were sprayed when the two unifoliate leaves were fully developed prior to the first trifoliate emerging. The study had five replications and two runs separated temporally. Applications were made using a single nozzle track sprayer at the same location. Three nozzles (XR, AIXR, and TTI) were evaluated at 138, 259, and 379 kPa. The dicamba (0.14 kg ae ha¹) spray solution was applied alone and with NIS, COC, MSO, silicone, or a drift reduction adjuvant (DRA) and contained a tracer rhodamine dye. After plants were treated, the two leaves were immediately removed and rinsed with 40 ml of 1:10 isopropyl alcohol and distilled water solution to place the dye in a liquid suspension. This suspension was then analyzed using a fluorimeter to determine the concentration of dye that was present on the leaves. Data were corrected to account for leaf area and recovery. Dicamba spray retention when using the XR nozzle, which produced the smallest spray droplets, was 44 and 66% greater than the AIXR and TTI nozzle, respectively. The lowest application pressure (138 kPa) had the greatest dicamba spray retention compared to the higher pressures 259 and 379 kPa, which had 20 and 12% less retention, respectively. Applying dicamba without an adjuvant resulted in spray retention of 41, 49, 190, 192, and 272% less when than using DRA, COC, silicone, NIS, and MSO, respectively. Careful nozzle and pressure selection, in addition to using an appropriate adjuvant, can increase the amount of dicamba that is retained on the leaf surface.

COMPARISON OF FOUR VENTURI NOZZLES ON INJURY OF TOMATO FROM 2,4-D APPLICATIONS. Cody T. Dorn*[1], Danilo Pavani Correa[1], Jeffrey A. Golus[1], Ryan S. Henry[1], Cody F. Creech[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (93)

Evolution of herbicide-resistant weed species across the world has spurred the development of crops resistant to growth regulator herbicides. While the goal of these new technologies is to extend broadleaf weed control, a large focus has been placed on mitigating off-target movement of the new pesticides. Field scale evaluations of pesticide drift reduction technologies can be a critical component in the proposed verification process established by the US EPA Drift Reduction Technology Program. Unfortunately, field evaluations are often marked by several difficulties, including financial constraints, weather variables, and large labor requirements. It would therefore be advantageous to evaluate the relative differences between the drift potential of application technologies in a more controlled setting. To this end, a series of simulated drift experiments were conducted in a low speed wind tunnel at the Pesticide Application and Technology Laboratory in North Platte, NE. At six locations downwind of the application site, collection stations consisting of a mylar card, string, and tomato (*Solanum lycopersicum*) plants were placed in order to measure downwind deposition, airborne movement, and damage, respectively. The mylar cards and strings were analyzed using fluorometric techniques and the tomato plants were placed into a greenhouse and visual estimations of injury were collected at 7, 14, 21, and 28 days after treatment. The application technologies tested were nozzle design and Enlist Duo™. Results were compared to the standard treatment, which was Enlist Duo™ sprayed with an AIXR11004 nozzle. The study showed significant reductions in drift using the Enlist Duo™ formulation compared to a tank-mixture of glyphosate (Roundup PowerMax™) and 2,4-D (Weedar 64™). We also found that nozzles made a significant difference in drift reduction. However, droplet size was not always correlated to drift reduction.

GROUND SPRAY 2.0 - AN IMPROVED DROPLET SIZE CALCULATOR. Jeffrey A. Golus*[1], Ryan S. Henry[1], Lowell D. Sandell[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (94)

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 chemistries of the tank-mixtures. 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 tool will allow the user to quickly determine the droplet size and quality of an application with user-defined parameters. Ground Spray also allows the user to save and/or send the results to another party in real time. 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.

EVALUATION OF SPRAY PARTICLE SIZE, SPRAY PATTERN UNIFORMITY, AND DROPLET VELOCITY OF FOUR GROUND NOZZLES. Ryan S. Henry*[1], Bradley K. Fritz[2], Clint W. Hoffmann[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA-ARS, College Station, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (95)

Understanding spray droplet size, pattern uniformity, and droplet velocity of pesticide applications is important to mitigate drift and maintain efficacy. Small spray particles are more drift prone than large particles, although previous research has indicated that particle size can affect final efficacy. Applicators can alter particle size in a variety of ways, including nozzle selection, operating pressure, and adjuvant inclusion. There is little information on how these parameters affect spray pattern uniformity and droplet velocity in the current literature. A series of experiments were conducted at the PAT Lab in North Platte, NE to measure the droplet size, pattern uniformity, and droplet velocity from four different ground nozzles, four operating pressures, and four glyphosate solutions. Droplet size was measured in a low speed wind tunnel coupled with a Sympatec HELOS/KR laser diffraction system. Pattern uniformity was measured using a spray pattern table. Droplet velocity was measured using a LaVision FlowMaster system. Nozzle type had the largest effect on the three parameters measured. The venturi-type nozzles had a larger droplet spectrum compared to the flat fan nozzle, with the largest droplet spectrum attributed to the

TeeJet TTI nozzle. Droplet velocity was lower with venturi-type nozzles across the droplet spectrum measured, particularly at droplet sizes less than 200 microns and lower operating pressures. Between five and ten percent reduction in pattern uniformity was measured in the venturi-type nozzle as compared to the flat fan nozzle. The data from this study will be useful to applicators because it provides a more complete analysis of pesticide application characteristics than examining a single metric. Future studies can expand on this dataset by including more nozzle, pressure, and solution combinations.

AN EVALUATION OF A HOODED SPRAYER FOR PESTICIDE DRIFT REDUCTION. Strahinja Stepanovic*[1], Ryan S. Henry[2], Steven Claussen[3], Greg R. Kruger[4]; [1]University of Nebraska-Lincoln, Grant, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Willmar Fabrication, Wilmar, MN, [4]University of Nebraska-Lincoln, USA, Lincoln, NE (96)

Environmental concerns regarding off-target of movement of herbicides has become incrementally more pressing in recent years with increased focus on the safety of humans and the environment, and with detection tools that have increasing resolution. A field study was conducted at West Central Research and Extension Center (WCREC) in North Platte, NE to evaluate effectiveness of using a hooded sprayer in reducing drift potential. A solution of glyphosate (RoundUp Powermax; 0.84 kg ae/ha), 5%v/v ammonium sulfate (AMS) and a rhodamine florescent dye with water as a carrier were applied at 94 l/ha rate to 38 cm soybean canopy at R1 stage using four different nozzle/pressure combinations (XR1002 at 400 kPa, XR11003 at 200 kPa, AI11002 at 200 kPa, AI11002 at 400 kPa) and two sprayers (hooded or non-hood). The sprayers were driven at constant speed of 6.4 km/h for 215 m (in west-east direction) and the sprayers were set with 76 cm nozzle spacing, and placed 61 cm above soybean canopy; predominant wind was south, blowing at 16 km/ha. Collection line was laid out perpendicular to the drive line with collection strings placed at 5, 10, 14, 18, 23, 27 and 32 m distance and 61 cm above the ground surface. The collection strings were washed with 40 mL distilled water and analyzed using a fluorimeter. Preliminary results indicate that hooded sprayer reduced spray drift to <2% at any measured distance, except for XR11002 at 400 kPa, which had an average of 4% drift across all distances. When herbicide solution was sprayed without hood there was <4% drift observed at all distances and all nozzles, except for AI11002 which also had <4% drift at distances larger than 18 m, but an average of 18, 8 and 7% drift at 5, 10 and 14 m distance from the spray source, respectively. Hooded sprayer in combination with appropriate nozzle can greatly reduce off-target movement and reduce the environmental concerns associated with application of glyphosate or other herbicides in the future.

TANK MIXTURES OF GLYPHOSATE OR GLUFOSINATE WITH GROWTH REGULATORS. Sjdjan Cirovic*[1], Ryan S. Henry[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, NORTH PLATTE, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (97)

Chemical weed control management in row crops has become highly predicated on having highly effective postemergence (POST) herbicide options. However, POST applications in soybean are limited to a few herbicide mode of actions, and the impending adoption of 2,4-D- and dicamba-tolerant technologies will add one more mode of action to list for soybean producers. However, our understanding of how to implement these technologies with glyphosate- or glufosinate-resistant technology is limited. Tank-mixtures can have an additive, synergistic or antagonistic response. The objective of this study was to understand how combinations of glyphosate or glufosinate react with 2,4-D or dicamba. This study was completed at the PAT Lab in North Platte, NE utilizing a single nozzle track sprayer in a spray chamber and greenhouse. Four plant species (grain amaranth, common lambsquarters, shattercane, and velvetleaf) were applied with one of the following: glyphosate, glufosinate, 2,4-D, dicamba, glyphosate + 2,4-D, glyphosate + dicamba, glufosinate + 2,4-D or glufosinate + dicamba. Plants were sprayed with a TTI11002 at 276 kPa with 9.6 kph expect solutions with glufosinate which were sprayed at 6.2 kph to get 97 l/ha and 147 l/ha, respectively. The study was conducted in two runs with four replications in each run. Tank-mixtures of 2,4-D or dicamba with glyphosate increased or maintained the control observed with glyphosate alone. The same was true for 2,4-D or dicamba with glufosinate compared to glufosinate alone. We did not observe antagonistic effects between either growth regulator herbicide with glyphosate or glufosinate. In some cases, however, synergist effects were observed. The best example was in common lambsquarters where glufosinate alone had 5% reduction in dry weight, dicamba alone had a 12% reduction in dry weight, but the tank-mixture of the two herbicides together had a 51% reduction in dry weight. Further research is need to better understand the relationship of these tank-mixtures, but it appears as though there is an opportunity to significantly increase POST weed control programs though tank-mixtures of glyphosate or glufosinate with growth regulator herbicides.

WELCOME TO MINNEAPOLIS. Bev Durgan*; University of Minnesota, St. Paul, MN (98)

No abstract submitted

WASHINGTON SCIENCE POLICY UPDATE. Lee Van Wychen*; National and Regional Weed Science Societies, Washington, DC (99)

No abstract submitted

TURFGRASS MANAGEMENT FOR PROFESSIONAL SPORTS. Larry DiVito*; Minnesota Twins Baseball Club, Minneapolis, MN (100)

No abstract submitted

NCWSS PRESIDENTIAL ADDRESS. JD Green*; University of Kentucky, Lexington, KY (101)

No abstract submitted

NECROLOGY REPORT. Joe Armstrong*; Dow AgroSciences, Davenport, IA (102)

No abstract submitted

COMPARISON OF SINGLE MODE OF ACTION HERBICIDES APPLIED PREEMERGENCE TO GLYPHOSATE-RESISTANT PALMER AMARANTH IN INDIANA. Joseph T. Ikley*[1], Travis R. Legleiter[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (103)

Palmer amaranth (*Amaranthus palmeri*) is a growing problem in Indiana, with 40% of counties across the state having confirmed infestations. Preliminary results from herbicide screens from populations across the state indicate that most populations are resistant to glyphosate (Group 9 herbicide) and ALS-inhibiting herbicides (Group 2 herbicides). The widespread resistance to Group 2 and Group 9 herbicides limits postemergence options in soybean to PPO-inhibiting herbicides (Group 14 herbicides). The need to relieve selection pressure from the single effective postemergence option places greater emphasis on using effective preemergence (PRE) herbicides in fields infested with Palmer amaranth. In 2014, a field experiment was established on a glyphosate-resistant Palmer amaranth population near Twelve Mile, IN to compare commercially available single mode of action herbicides applied PRE in soybean for their control of Palmer amaranth. Herbicide treatments consisted of three Group 15 herbicides (acetochlor at 1260 g ha^{-1}, s-metolachlor at 1070 g ha^{-1}, and pyroxasulfone at 179 g ha^{-1}), one Group 5 herbicide (metribuzin at 420 g ha^{-1}), and two Group 14 herbicides (flumioxazin at 71.5 g ha^{-1}, and sulfentrazone at 175 g ha^{-1}). The location has a loamy fine sand soil type with 2.1% organic matter and a cation exchange capacity of 8.5. The site experienced cool, wet weather conditions for two weeks after application with an average daily temperature of 15 C and 11 cm of precipitation. At 21 days after treatment (DAT), all treatments provided ≥90% Palmer amaranth control except for metribuzin, which provided 77% control. At 30 DAT, pyroxasulfone and the Group 14 herbicides still provided ≥90% control, while acetochlor and s-metolachlor provided 73% and 70% control, respectively. Metribuzin had the lowest control (27%) at 30 DAT. At 56 DAT, there were no differences between pyroxasulfone and the Group 14 herbicides, with control ranging from 61-93%, while acetochlor, s-metolachlor, and metribuzin all provided ≤40% control. Results from this study indicate that pyroxasulfone and the Group 14 herbicides provide more residual control of Palmer amaranth when applied PRE on coarse soils than other Group 15 herbicides and metribuzin. These results will help with selection of PRE herbicides in planned multiple-pass systems to provide season-long Palmer amaranth control.

COMPARISON OF HERBICIDE MODE OF ACTION COMBINATIONS APPLIED PREEMERGENCE TO GLYPHOSATE-RESISTANT PALMER AMARANTH IN INDIANA. Joseph T. Ikley*[1], Travis R. Legleiter[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (104)

Palmer amaranth (*Amaranthus palmeri*) is a growing problem in Indiana, with 40% of counties across the state having confirmed infestations. Preliminary results from herbicide screens from populations across the state indicate that most populations are resistant to glyphosate (Group 9 herbicide) and ALS-inhibiting herbicides (Group 2 herbicides). The widespread resistance to Group 2 and Group 9 herbicides limits postemergence options in soybean to PPO-inhibiting herbicides (Group 14 herbicides). The need to relieve selection pressure from the single effective postemergence option places greater emphasis on using effective preemergence (PRE) herbicides in fields infested with Palmer amaranth. In 2014, a field experiment was established on a glyphosate-resistant Palmer amaranth population near Twelve Mile, IN to compare combinations of Group 14, Group 15, and Group 5 herbicides applied PRE in soybean for their control of Palmer amaranth. Group 14 herbicides selected were flumioxazin and sulfentrazone. Group 15 herbicides selected were acetochlor, pyroxasulfone, and *s*-metolachlor. Metribuzin was the only Group 5 herbicide used. The six active ingredients listed above were compared through a combination of pre-packaged commercial herbicides and tank-mixes of pre-packaged commercial herbicides with the addition of the single active ingredient herbicides. At 21 days after treatment (DAT), all herbicide combinations provided 100% control with the exception of *s*-metolachlor plus metribuzin, which provided 92% control. At 42 DAT, the tank mix *s*-metolachlor plus metribuzin provided the lowest control (58%), while every other treatment provided ≥ 80% control. Overall treatment control levels declined in the period between 42 and 56 DAT. At 56 DAT, treatment combinations containing flumioxazin plus a Group 15 herbicide provided 83 to 93% control. Sulfentrazone plus a Group 15 herbicide provided 67 to 85% control at the same rating timing. Metribuzin tank mixed with a Group 15 herbicide resulted in more variable weed control with 47 to 76% Palmer amaranth control at 56 DAT. Results indicate that combining a Group 14 and a Group 15 herbicide provide excellent early season control of Palmer amaranth and can play a key role in developing herbicide programs to provide season-long control of this problematic weed.

CURRENT STATUS OF HERBICIDE RESISTANCE IN SHATTERCANE AND JOHNSONGRASS POPULATIONS FROM NORTHERN KANSAS, EASTERN MISSOURI AND SOUTHERN NEBRASKA. Rodrigo Werle*[1], Amit J. Jhala[1], Melinda K. Yerka[2], John L. Lindquist[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]USDA-ARS, Lincoln, NE (105)

Traditional breeding technology is currently being used to develop grain sorghum germplasm that will be tolerant to acetolactate synthase (ALS)-inhibiting herbicides. Use of ALS-inhibitors for weed control during the 1980's and 1990's resulted in the evolution of resistance to ALS-inhibitors in shattercane, a weedy relative of sorghum prevalent in Nebraska. The objective of this study was to assess the baseline presence of ALS resistance in populations of shattercane and johnsongrass, another weedy sorghum relative. The populations were obtained from numerous locations, including where known resistance occurred in the past in Nebraska. In the fall of 2013, seeds from 190 shattercane and 58 johnsongrass populations were collected from northern Kansas, western Missouri, and southern Nebraska. In the summer of 2014, a preliminary field experiment was conducted near Mead, NE to evaluate the presence or absence of herbicide resistance in the aforementioned populations. Treatments consisted of four herbicides applied at their labeled rate: clethodim, glyphosate, imazethapyr and nicosulfuron. Clethodim and glyphosate controlled all shattercane and johnsongrass populations evaluated. Some populations showed signs of resistance to imazethapyr and/or nicosulfuron. Putative ALS-resistant populations were evaluated under greenhouse conditions. Nicosulfuron and imazethapyr were applied at their labeled rate to 23 plants of each population 3 weeks after planting (plants were at V3-V4 growth stage). ALS-tolerant and susceptible sorghum were included as controls. Plant mortality (%) and visual injury data were collected 21 DAT. For shattercane, 6 and 8 populations were resistant to nicosulfuron and imazethapyr, respectively, with 4 populations being cross-resistant to ALS inhibitors (both nicosulfuron and imazethapyr). For johnsongrass, 3 and 9 populations were resistant to nicosulfuron and imazethapyr, respectively, with 3 populations being cross-resistant to ALS-inhibitors. The level of resistance varied greatly across populations. Results from the field and greenhouse work were in close agreement. Most of the ALS-resistant populations were collected from south-central and eastern Nebraska and north-east Kansas. Even though ALS inhibitors have not been widely used to control shattercane and johnsongrass since the commercialization of glyphosate-tolerant crops, the resistance trait is still present in locations where resistance was reported in the 1990's, indicating the lack of a strong fitness cost associated with ALS-resistance in weedy sorghum populations. Molecular and dose-response work are being conducted to further explore the underlying mechanism and levels of resistance. The results of this research will identify regions where shattercane and johnsongrass should be carefully managed prior to and during the commercialization of ALS-tolerant sorghum.

CONTROL AND DISTRIBUTION OF GLYPHOSATE RESISTANT COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L.) IN ONTARIO. Annemarie C. Van Wely*[1], Peter H. Sikkema[1], Darren Robinson[1], David C. Hooker[1], Mark B. Lawton[2]; [1]University of Guelph, Ridgetown, ON, [2]Monsanto Canada, Guelph, ON (106)

Glyphosate resistant (GR) weeds have developed following the repeated use of glyphosate in GR crops. An Ontario population of common ragweed was found to be resistant to glyphosate in 2011. In 2012 and 2013, field surveys were conducted to document the distribution of the resistant biotype, where four additional sites were found with GR common ragweed in Essex County. Field experiments were conducted to assess alternative control options in Roundup Ready (GR) and Roundup Ready 2 Xtend (glyphosate plus dicamba resistant) soybean (*Glycine max* L. Merr.). The three objectives of the research were to determine: a) the biologically effective rate of glyphosate for the control of a resistant and susceptible biotype of common ragweed, b) the efficacy of glyphosate tankmixes applied preplant and postemergence, and c) the efficacy of dicamba for the control of GR common ragweed in Roundup Ready 2 Xtend soybean. Linuron and metribuzin provided the highest and most consistent preplant control of GR common ragweed (>80%) 28 and 56 days after application. The postemergence herbicides did not provide commercially acceptable control of GR common ragweed. Dicamba in Roundup Ready 2 Xtend soybean controlled GR common ragweed.

GLYPHOSATE-RESISTANT COMMON WATERHEMP IN NEBRASKA: CONFIRMATION AND CONTROL IN SOYBEAN. Debalin Sarangi*[1], Lowell D. Sandell[1], Stevan Z. Knezevic[2], Jatinder S. Aulakh[3], John L. Lindquist[1], Suat Irmak[3], Amit J. Jhala[4]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]University of Nebraska- Lincoln, Lincoln, NE, [4]University of Nebraska-Lincoln, USA, Lincoln, NE (107)

Widespread-adoption of glyphosate-tolerant crops and overreliance on glyphosate for weed control imposed a selective advantage, resulting in the evolution of glyphosate-resistant weeds. Common waterhemp (*Amaranthus rudis* Sauer) is one of the most commonly encountered and difficult-to-control broadleaf weeds in no-till agricultural fields in Nebraska. The objectives of this study were to confirm the occurrence of glyphosate-resistant common waterhemp in Nebraska by quantifying the level of resistance in a dose response study and to evaluate the efficacy of POST soybean herbicides to control suspected glyphosate-resistant common waterhemp biotypes. Glyphosate dose response experiments were conducted in greenhouse with suspected glyphosate-resistant common waterhemp biotypes collected from seven eastern Nebraska Counties (Antelope, Dodge, Fillmore, Lancaster, Pawnee, Seward, and Washington). Results indicated that common waterhemp biotypes were 3 to 39- fold resistant to glyphosate depending upon the biotypes being investigated and susceptible biotype used for comparison. Soybean POST herbicide efficacy study revealed that all the glyphosate-resistant common waterhemp biotypes, except the biotype from Pawnee County, had reduced sensitivity to acetolactate synthase (ALS) inhibiting herbicides (chlorimuron-ethyl, imazamox, imazaquin, imazethapyr, thifensulfuron-methyl) applied at labeled rates. Additionally, the results suggested that the glyphosate-resistant common waterhemp biotypes can be controlled effectively (≥80%) by application of glufosinate and protoporphyrinogen oxidase (PPO) inhibiting herbicides (acifluorfen, fluthiacet-methyl, fomesafen, and lactofen). This study confirmed the presence of glyphosate-resistant common waterhemp in Nebraska for the first-time and also revealed the occurrences of multiple- and cross-resistance to ALS-inhibiting herbicides in most of the biotypes tested in this study.

INTEGRATED MANAGEMENT OF GLYPHOSATE-RESISTANT GIANT RAGWEED WITH TILLAGE AND HERBICIDES IN SOYBEAN. Zahoor A. Ganie*[1], Lowell D. Sandell[1], John L. Lindquist[1], Greg R. Kruger[2], Mithila Jugulam[3], Amit J. Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE, [3]Kansas State University, Manhattan, KS (108)

Glyphosate-resistant giant ragweed is one of the most competitive and difficult to control annual weeds in soybean. Giant ragweed control is complicated due to its early emergence, rapid growth, high plasticity in plant vigor, and limited POST-herbicide options in soybean. Therefore, early season giant ragweed control is very critical to avoid yield loss. The objective of this study was to evaluate the control of glyphosate-resistant giant ragweed through integration of preplant tillage or 2,4-D burndown application with PRE and/or POST herbicide mixtures. Two field trials were conducted over a 2-yr period (2013 and 2014) at David City, NE, on a farm infested with glyphosate-resistant giant ragweed. Preplant tillage and 2,4-D burndown application provided 95% and 69% control of glyphosate-resistant giant ragweed, respectively, 10 d after application. Giant ragweed control and biomass reduction was consistently higher (both >90%) with preplant tillage or 2,4-D burndown application followed by PRE and/or POST herbicide mixtures, compared to <85% with PRE and/or POST herbicide mixtures only. The soybean yield with preplant tillage or 2, 4-D burndown application *fb* PRE and/or POST herbicide mixtures was >2500 kg ha^{-1} compared to <1800 kg ha^{-1} under only PRE and/or POST herbicide mixtures. The results of this study suggest that integration of early season management by preplant tillage or 2,4-D burndown application with PRE and/or POST herbicides, has a positive influence on giant ragweed control and increase in soybean yield.

DOSE RESPONSE OF GLYPHOSATE-RESISTANT WEEDS TO ENLIST DUO™ APPLIED AT TWO GROWTH STAGES. Parminder S. Chahal*[1], Jatinder S. Aulakh[2], Amit J. Jhala[1], Kristin Rosenbaum[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Field Scientist, Crete, NE (109)

Glyphosate-resistant weeds are a serious threat to the row crop producers in the Midwest, especially in no-till production systems that primarily rely on herbicides for weed control. Growers are in a need of weed management technologies or herbicides to augment glyphosate performance. With the intent to control both glyphosate-resistant and -susceptible weeds, a new weed control system, which includes a pre-mix of glyphosate dimethylamine and 2,4-D choline (Enlist Duo™ herbicide), has been developed by Dow AgroSciences. The objectives of this study were to determine effective rates of the pre-mix of glyphosate and 2,4-D choline to control glyphosate-resistant weed species including common waterhemp, giant ragweed, and kochia, and to determine the effect of growth stage of the weed species on efficacy of this herbicide. Dose response studies were conducted under greenhouse conditions. Four parameter log-logistic models were used to analyze visual control ratings and dry weight reduction data versus herbicide rates. Glyphosate-resistant giant ragweed was the most sensitive followed by glyphosate-resistant common waterhemp, while glyphosate-resistant kochia was the least sensitive to this herbicide. Efficacy was affected by growth stage of weeds. The estimated rates required for 90% control (ED_{90}) of common waterhemp, giant ragweed, and kochia were 1,190, 512, and 4,330 g ae ha^{-1}, respectively, for 10-cm tall plants compared to 3,816, 1,264, and 6,569 g ae ha^{-1}, respectively, for 20-cm tall plants. The ED_{90} values calculated on the basis of percent dry weight reduction were usually similar to the visual control estimates at 21 days after treatment (DAT). These greenhouse studies indicate that this pre- mixture can effectively control ≤ 20-cm tall glyphosate-resistant giant ragweed and ≤ 10-cm tall glyphosate-resistant common waterhemp at the labeled rate of 1,640 g ae ha^{-1}.

CONFIRMATION OF HPPD RESISTANT COMMON WATERHEMP IN NEBRASKA. Maxwel C. Oliveira*[1], Jon E. Scott[2], Aaron S. Franssen[3], Vinod K. Shivrain[4], Stevan Z. Knezevic[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]Syngenta Crop Protection, Seward, NE, [4]Syngenta, Greensboro, NC (110)

HPPD-common waterhemp has been confirmed in three states (Illinois, Iowa and Nebraska) over the last five years. This resistance type limits herbicide options for managing common waterhemp in corn. The objective of this study was to conduct a dose response study to confirm HPPD resistance in common waterhemp biotypes in Nebraska. Therefore, field studies were conducted with suspected waterhemp population in Madison County, NE. Each of the tree herbicides (mesotrione, tembotrione and topramezone) was applied at five doses (0, 1x, 2x, 4x, and 8x of the label rates) and at two application times (8 and 15 cm tall waterhemp). Weed control was visually evaluated weekly until 28 DAT, and weed dry matter was collected. Based on visual injury ratings and dry matter reduction, dose response analysis was performed to determine ED_{50}, and ED_{90} values for control of 8 and 15 cm tall waterhemp for each herbicide. HPPD resistance was confirmed for each of the three herbicides. The estimated level of resistance in 8 cm tall waterhemp to mesotrione, tembotrione, and topramezone was 12, 6, and 3x, respectively. Furthermore, the estimated level of resistance in 15 cm tall waterhemp to mesotrione, tembotrione, and topramezone was 19, 9, and 3x the label rate, respectively. While levels of resistance to tembotrione and topramezone were not as high as for mesotrione, the waterhemp population was still confirmed to be resistant. From the practical standpoint, we believe that the use-pattern of HPPD herbicides should be carefully managed, and an integrated weed management plan involving alternative weed control tools and herbicide plan with multiple modes of actions should be utilized.

HERBICIDES TO MANAGE PUTATIVE HPPD-RESISTANT WATERHEMP IN CORN. Damian D. Franzenburg*, Micheal D. Owen, James M. Lee, Jacob S. Eeling; Iowa State University, Ames, IA (111)

Weed control in production seed corn is difficult to achieve because inbred corn does not provide a canopy that competes with weeds for resources. HPPD herbicides have been used heavily in seed corn production the past decade because of the broad spectrum weed control and adequate crop safety provided. However, recently some seed corn production fields have waterhemp (*Amaranthus tuberculatus syn. Rudis*) populations increasingly difficult to control with this group of herbicides. This research investigated herbicide combinations that include multiple modes of action to manage waterhemp populations in a seed corn production field near Reinbeck, Iowa with a history of poor waterhemp control with HPPD herbicides. The experiments included one with treatments having multiple applications and one comparing postemergence and postemergence following preemergence herbicide treatments. The experimental design for both trials was randomized complete block with three replications. Corn was planted at 76 cm row spacing on corn ground that was left un-tilled from the previous corn cropping season 2013. Plots were 3 by 7.6 m. All plots received a burndown application of glyphosate (1260 g ai/ha) four days after planting. At the POST application timing, PRE applications of acetochlor, acetochlor plus atrazine, pyroxasulfone and pyroxasulfone tank mixed with isoxaflutole and atrazine were similar for waterhemp control within respective experiments and provided significantly greater waterhemp control than dimethenamide, dimethenamide plus atrazine, metolachlor and isoxaflutole within respective experiments. At 13 days after treatment (DAA), POST herbicides mesotrione and tembotrione gave poor waterhemp control. POST fluthiacet-methyl plus mesotrione provided 82% control. When POST treatments were tank mixed with atrazine, mesotrione efficacy improved to 92%. Fluthiacet-methyl plus mesotrione control only improved to 88% with atrazine. Tembotrione control of waterhemp was still unacceptable at 78% when tank mixed with atrazine. By 41 DAA, fluthiacet-methyl plus mesotrione and mesotrione tank mixed with atrazine provided 78 and 80% control, respectively. No other POST treatments provided more than 68% control. POST applications of diflufenzopyr plus dicamba plus isoxadifen-ethyl initially provided significantly greater control when following PRE acetochlor or acetochlor plus atrazine than when tank mixed with dimethenamide or dimethenamide plus atrazine following PRE dimethenamide and dimethenamide & atrazine at 13 DAA. However, by 41 DAA, control was similar among these treatments and also PRE pyroxasulfone tank mixed with isoxaflutole and atrazine followed by POST dicamba plus safener. Control ranged from 77 to 86%.

REVISITING TRAILLATE FOR WILD OAT CONTROL IN WHEAT. Morgan D. Hanson*, Kirk A. Howatt; NDSU, Fargo, ND (112)

Herbicide resistant weed populations have increased because of continuous use of the same grass herbicides. Several collections of wild oat with resistance to ACC-ase and ALS herbicides have been documented in North Dakota, leaving limited options for control. Triallate is an option for wild oat control, but resistance has been documented. Two separate experiments were conducted in 2014 to evaluate the efficacy of triallate to control wild oat and determine spring wheat cultivar tolerance to triallate. Wild oat control studies, located in Fargo, ND and Neilsville, MN, consisted of seven treatments including an untreated check, triallate, propoxycarbazone, flucarbazone, and pyroxasulfone. Triallate at 1120 g ha^{-1} provided as much as 95% control of wild oat, compared to 80 to 90% control at 560 g ha^{-1}. Pryoxasulfone demonstrated the highest rating of 97% control in one location. Crop injury studies, located in Fargo and Prosper, ND, evaluated injury to wheat at triallate rates ranging from 840 to 2240 g ha^{-1}. Overall, plant populations across cultivars were not significantly different between the low and high rates. Injury ranged from 6 to 32% across cultivars with triallate at 840 g ha^{-1}. However, at 2240 g ha^{-1}, Glenn showed the lowest crop injury of 52% compared to Stingray with up to 80%. Therefore, triallate may be a suitable option due to adequate wild oat control, although injury indicates need for further crop tolerance study.

INFLUENCE OF VARIOUS COVER CROP SPECIES ON WINTER AND SUMMER ANNUAL WEED EMERGENCE. Cody D. Cornelius*; University of Missouri, Columbia MO, MO (113)

In recent years, cover crops have become a more popular component of corn and soybean production systems in the Midwest. One reason for the increased popularity is due to claims that certain cover crop species have the ability to reduce subsequent weed emergence. A field experiment was conducted at two locations in 2013 and 2014 to determine the effects of wheat (*Triticum* aestivum), cereal rye (*Secale cereale*), annual ryegrass (*Lolium multiflorum*), oats (*Avena sativa*), tillage radish (Raphanus sativus), crimson clover (*Trifolium incarnatum*), hairy vetch (*Vicia villosa*), Austrian pea (*Pisum sativum*) and a mix of cereal rye plus hairy vetch on cumulative winter and summer annual weed emergence in soybean. All cover crop species were established in the fall and received a burndown application of glyphosate plus 2,4-D ester in the spring approximately 7 to 14 days prior to soybean planting. These cover crop species were compared to two herbicide programs; glyphosate plus 2,4-D plus sulfentrazone plus chlorimuron in the fall, and a spring burndown treatment of glyphosate plus 2,4-D plus sulfentrazone plus cloransulam followed by an in crop application of glyphosate plus fomesafen plus *S*-metolachlor. Counts of all emerged weeds were made in two, 1 m^2 quadrats within each plot every two weeks beginning April 15th in 2013 and April 9th in 2014 and continuing through crop canopy. Following each count glufosinate was applied to eliminate all emerged weed species for that two-week period. Across all locations, cover crop species reduced cumulative winter annual weed density 20 to 74% compared to the non-treated control. Cereal rye and the cereal rye plus hairy vetch mix reduced winter annual weed densities by 70 and 74%, respectively, but were not as effective as the fall herbicide treatment which reduced winter annual weeds by 99%. Similarly, only cereal rye and the cereal rye plus hairy vetch mix reduced cumulative summer annual weed emergence compared to the non-treated control. Cereal rye and the mix of cereal rye plus hairy vetch reduced cumulative summer annual weed emergence 40 and 54%, respectively, and provided similar reductions in cumulative summer annual weed emergence as the spring burndown treatment of glyphosate plus 2,4-D plus sulfentrazone plus cloransulam followed by in-crop application of glyphosate plus fomesafen plus *S*-metolachlor. However, two weeks after the in crop application of glyphosate plus fomesafen plus *S*-metolachlor, this treatment reduced weed densities by 90% whereas all other cover crop species reduced weed densities by 52% or less. The results from this research indicate that most cover crop species can provide some degree of winter annual weed control, but only certain species like cereal rye can have a substantial impact on summer annual weed emergence.

LIGHT INTERCEPTION IN SOYBEAN DETERMINED THROUGH DIGITAL IMAGERY ANALYSIS AFFECTS SOYBEAN YIELD AND WEED SUPPRESSION. Thomas R. Butts*[1], Jason K. Norsworthy[2], Greg R. Kruger[3], Lowell Sandell[4], Bryan Young[5], Lawrence E. Steckel[6], Mark M. Loux[7], Kevin W. Bradley[8], William G. Johnson[9], Vince M. Davis[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Arkansas, Fayetteville, AR, [3]University of Nebraska-Lincoln, USA, Lincoln, NE, [4]Valent USA Corporation, Lincoln, NE, [5]Purdue University, W. Lafayette, IN, [6]University of Tennessee, Jackson, TN, [7]Ohio State University, Columbus, OH, [8]University of Missouri, Columbia, MO, [9]Purdue, West Lafayette, IN (114)

Digital imagery analysis provides a unique option to determine soybean light interception (LI) throughout the growing season. Subsequently, LI is used to calculate cumulative intercepted photosynthetically active radiation (CIPAR) which has been shown to affect soybean yield. This research evaluates whether early-season soybean CIPAR also has an effect on the amount of pigweeds (*Amaranthus spp.*) present at the postemergence (POST) herbicide application timing. A field study was conducted in cooperative effort with seven universities across eight locations in 2013 representing eight site-years. Locations were combined relative to their optimum adaptation zone for soybean maturity groups. The North region was comprised of Nebraska, Ohio, and Wisconsin, and the South region was comprised of Arkansas, Southern Illinois, and Tennessee. Two row widths (≤38 and ≥76 cm), three seeding rates (173,000, 322,000, and 470,000 seeds ha^{-1}), and two herbicide strategies (preemergence plus postemergence (PRE + POST) vs. POST-only) were arranged in a randomized complete block split-plot design with row width as the main plot factor and a 3x2 factorial of seeding rate and herbicide strategies as the subplots. Across all locations, PRE applications were made within two days of planting, POST-only applications were made approximately 14 days after the V1 (DAV1) soybean growth stage, and POST following PRE applications were made 28 to 35 DAV1. Pigweed density was measured prior to the POST herbicide applications and soybean harvest. Digital images of each plot were taken weekly from V1 to August 1 and analyzed using SigmaScan Pro 5® software to provide weekly LI percentages. Quadratic models were fit for each plot to estimate daily LI percentages from V1 to 50 DAV1 for each location, and subsequently used with daily average solar radiation estimates to calculate CIPAR. CIPAR was then summed for 29 DAV1 (early-season CIPAR) for analysis with pigweed densities at the POST herbicide application and summed for 50 DAV1 (total CIPAR) for analysis with soybean yield. Early-season CIPAR was inversely correlated with pigweed density at the POST herbicide application in the North ($R^2=0.3363$) and South ($R^2=0.1272$) regions. A one MJ m^{-2} increase in early-season CIPAR led to a decrease of one pigweed m^{-2} in both regions. A PRE + POST herbicide strategy increased early-season CIPAR in the North ($P=0.0300$) and South ($P=0.0236$) regions by 23.55 and 16.46 MJ m^{-2}, respectively. Similarly, this herbicide strategy significantly increased total CIPAR in the North ($P=0.0212$) and South ($P=0.0166$) regions by 29.79 and 18.35 MJ m^{-2}, respectively. An increase in seeding rate of 148,000 seeds ha^{-1} was required to achieve an equivalent increase in CIPAR. Furthermore, a PRE + POST herbicide strategy increased yields in both the North ($P=0.0400$) and South ($P=0.0329$) regions by 458 and 377 kg ha^{-1}, respectively. Soybean yield was positively correlated with total CIPAR for both the North ($R^2=0.2010$) and South ($R^2=0.2200$) regions. In conclusion, through digital imagery analysis we determined a PRE + POST herbicide strategy increases early-season and total CIPAR in both North and South regions of the Midwest. The increase in CIPAR aids in both weed suppression and soybean yield. To support these conclusions, data from 2014 will be analyzed to provide 16 total site-years.

COMPETITIVE INTERACTIONS OF FOUR AMARANTHACEAE SPECIES WITH SOYBEANS. Lauren M. Schwartz*[1], Bryan Young[2], David J. Gibson[3]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN, [3]Southern Illinois University, Carbondale, Carbondale, IL (115)

Some of the most problematic agricultural weeds found in the Midwest United States are found in the Amaranthaceae family, such as *Amaranthus palmeri* and *A. tuberculatus*. These summer annual weeds are troublesome due to their competitive ability, high seed production, and resistance to herbicides from several modes of action; which complicates management in field crops and has led to significant yield loss. *Achyranthes japonica* and *Iresine rhizomatosa* are two perennial species in the same family as *A. palmeri* and *A. tuberculatus* that occur in similar habitats as one another, but differ in invasiveness. *Achyranthes japonica* is a non-native, invasive species that is becoming a threat to forested areas and has been observed along agricultural field margins. *Iresine rhizomatosa* also occurs in forest habitats but is an endangered species in Illinois. The objective of this experiment was to determine the relative competitive effect and response of these four closely related species in comparison to soybean (*Glycine max*). In a field experiment, each weed species was grown at varying densities of 10, 30, or 90 seedlings per 15-cm diameter pot with or without two *G. max* plants, to simulate relative densities for *G. max* grown in a 76-cm wide row spacing. In a separate greenhouse experiment, each of the four Amaranthaceae species and *G. max* were grown as monocultures and were evaluated in a closed system to assess drawdown of an aboveground (light) and belowground (nitrogen) resource. Four resource manipulation treatments were implemented by adding nitrogen (ammonium nitrate) or by shading using a 60% shade cloth to simulate the use of fertilizer and forest canopy, respectively. In the field experiment, the competitive effect of the weed species on *G. max* (P=0.04) indicated that *A. tuberculatus* reduced *G. max* plant height the most, closely followed by *A. japonica* and *A. palmeri*. The competitive response of the weed species to the presence of *G. max* indicated that, in general, all of the weed species showed a reduction in height (P=0.03) compared to the weed species grown in monocultures. *Achyranthes japonica* did, however, show a slight increase in height when *G. max* was present (P=0.03). *Glycine max* (P=0.01) and the weed species, except *I. rhizomatosa*, (P=0.001) showed a similar competitive effect and response when aboveground biomass was measured. *Achyranthes japonica* attained the highest belowground biomass when grown as a monoculture and in the presence of *G. max* (P=0.001). The greenhouse experiment showed that when treatments were compared with the controls, the four species each drew down light significantly, but not nitrogen. Shading decreased the aboveground biomass of the weed species in comparison to unshaded controls (P=0.006). Supplemental nitrogen, however, increased the aboveground biomass of *Amaranthus palmeri* and *A. japonica* (P=0.08). These results suggest that *A. japonica* may be as competitive with *G. max*, under ideal conditions, in comparison with the two *Amaranthus* species; thus, *A. japonica* is potentially capable of causing *G. max* yield loss. On this basis, *A. japonica* is yet another potential threat to farmers if it is able to colonize agricultural fields.

DIFFERENCES IN FINAL BIOMASS AMONG GLYPHOSATE-RESISTANT AND GLYPHOSATE-SUSCEPTIBLE MATERNAL FAMILIES OF *CONYZA CANADENSIS* IN OHIO: A PILOT FIELD EXPERIMENT. Beres T. Zachery*, Allison A. Snow, Jason T. Parrish; Ohio State University, Columbus, OH (116)

To date, over 30 weed species have evolved resistance to glyphosate, which is considered to be the most commonly used herbicide worldwide. However, few studies of glyphosate-resistant (GR) species have tested for fitness costs, or even benefits, of GR in the absence of exposure to this herbicide. This information is needed to anticipate the continued spread and persistence of GR biotypes over time. *Conyza canadensis* (horseweed) is a self-pollinating, annual weed that was reported as GR in Ohio starting in 2003. Here, we compared the performance of maternal families with different levels of GR in a common garden experiment. We focused on individual maternal families, rather than pooled samples from many families, because some populations may represent mixtures of susceptible and resistant plants. Initially, we screened progeny of one maternal plant from each of 88 populations in southwest or northeast Ohio for resistance (see Poster #80). Approximately half of these biotypes (i.e., maternal seed families) were collected from no-till soybean fields in the fall of 2013, and the other half came from non-agricultural habitats. Rosettes of each biotype were screened for percent survival after treatment at three dosages: 1X (= 0.84 kg ae glyphosate/ha), 8X, and 20X, along with 0X controls. Based on a threshold of 80% survival at each dosage, these biotypes were ranked as susceptible (S), resistant (R), highly resistant (HR), or extremely resistant (ER; i.e., 80% survival at 20X). We then selected the 19 least resistant and 21 most resistant biotypes from the sampled populations, for a total of 40 biotypes to be compared in the common garden experiment. Eight of these biotypes were scored as S, 11 as R, two as HR, and 19 as ER. The experiment was established at two nearby, recently tilled fields, each with a randomized block design and 20 replicate plants per biotype, in Columbus, Ohio, in 2014. Performance was evaluated by recording survival, rosette size at four weeks after germination, days to bolting, days to flowering, final height, and biomass. We also recorded the timing and occurrence of pathogen damage, which was common; heavily damaged plants were excluded from other statistical analyses. Data analyses are ongoing and will be reported in the presentation. Initially, it appears that several of these biotypes showed statistically significant differences in the measured traits. We did not see clear differences due to varying levels of resistance, although sample sizes were limited in some cases.

EMERGENCE PATTERN OF HORSEWEED (*CONYZA CANADENSIS*); BEHAVIOR AS BOTH A WINTER AND SUMMER ANNUAL. Joseph D. Bolte*, Reid Smeda; University of Missouri, Columbia, MO (117)

Horseweed (*Conyza canadensis*), traditionally viewed as a winter annual and distributed widely throughout the Midwest, is observed to often emerge following soybean establishment in the spring. In many areas, horseweed has become more difficult to manage, as many plants are resistant to glyphosate as well as other herbicides. With fewer options to manage horseweed, understanding the emergence pattern of populations can influence the selection and timing of chemical programs. Studies were established in central and southeast Missouri in the fall of 2013. Seeds from eleven different populations across a north-south distance of 538 km were collected in mid-September and known densities were spread in replicated 1.2 by 1.2 m plots. Horseweed seedlings were counted every 2-3 weeks from early October through the following July. Averaged across all populations and only considering seedlings that emerged during the course of the study, fall (October through January) and spring emergence (March to July) in central MO averaged 67.6 and 32.4%, respectively. For southeast MO, emergence in fall and spring averaged 35.2 and 64.8% of the total emergence, respectively. For central MO, the month of greatest horseweed emergence occurred from mid-October to mid-November, with 38.6 % of the total emergence. In southeast MO, the month of greatest emergence was April, with 16.7% of the total emergence. For both locations, seedling emergence was observed during July 2014, suggesting the overall time period to consider horseweed management for precluding seed production was 9 months. An orthogonal comparison was made to determine if the pattern of horseweed emergence was associated with population expression of glyphosate resistance. Among glyphosate resistant (GR; 6 populations) and glyphosate susceptible (GS; 5 populations) horseweed, emergence in the fall in central MO averaged 68.8 and 66.4% of the total emergence, respectively. In southeast MO, fall emergence of GR and GS population averaged 31.5 and 38.9% of total emergence, respectively. Horseweed emergence for a diverse number of populations was greater in the fall compared to spring for a southern versus northern geography in MO. Changes in biology of horseweed emergence do not appear related to the plants expression of glyphosate resistance, but are strongly influenced by the geographical location where plants emerge.

EMERGENCE, GROWTH, AND FECUNDITY OF PALMER AMARANTH IN MICHIGAN CORN AND SOYBEANS. Jonanthon R. Kohrt*, Christy L. Sprague, Karen A. Renner; Michigan State University, East Lansing, MI (118)

Field experiments were conducted near Middleville, MI in 2013 and 2014 to determine the influence of corn and soybean on the growth and development of Palmer amaranth for three cohorts. Growth parameters evaluated included emergence, growth rate, time to stages of reproduction, and seed production. Weekly emergence counts were taken in two established 0.25 m^2 quadrats in each plot throughout the growing season. Additionally, 10 plants in each plot were marked on 2-week intervals to establish three different cohorts (early, mid, and late). Height measurements to determine growth rate and visual evaluations for reproductive stages were taken biweekly and weekly for 2013 and 2014, respectively. At plant maturity above ground biomass was harvested for dry weight; for male plants maturity was determined when pollination ceased and females were deemed mature 3-weeks after the onset of black seed. Seeds were counted by hand threshing all female reproductive structures, and generating an average seed weight for each sample to determine overall seed production per plant. In both years, the relative growth rate (RGR) was similar for the early and late cohorts across both crops; however RGR was quicker for the mid-season cohort in the presence of soybean compared with corn. Biomass accumulation was over 5 times greater for Palmer amaranth in soybean compared with corn for the early emerging plants in both years. Palmer amaranth seed production was greatest for the early emerging plants compared with the mid-season, and late emerging plants. Similar to the trends for biomass and RGR, seed production was 9 times greater for Palmer amaranth grown in soybean compared with corn. Palmer amaranth produced seed in corn and soybean regardless of emergence time. However, this research indicates that in Michigan planting corn and delaying Palmer amaranth emergence for 8 weeks after planting can reduce seed production by greater than 80%.

EMERGENCE PATTERNS OF WATERHEMP AND PALMER AMARANTH UNDER NO-TILL AND TILLAGE CONDITIONS IN SOUTHERN ILLINOIS. Lucas X. Franca*[1], Bryan Young[2], Julie M. Young[3], Joseph L. Matthews[3]; [1]Southern Illinois University Carbondale, CARBONDALE, IL, [2]Purdue University, W. Lafayette, IN, [3]Southern Illinois University, Carbondale, IL (119)

A thorough understanding of weed biology is fundamental for developing effective weed management strategies. The continued spread of glyphosate-resistant waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer (syn. *rudis*)] and Palmer amaranth [*Amaranthus palmeri* (S. Wats.)] has complicated weed management efforts in soybean and corn production in Illinois. The determination of emergence patterns and the influence of tillage on weed emergence will allow control strategies to be implemented at the most effective timing. The objective of this research was to characterize the emergence patterns of waterhemp and Palmer amaranth based on weather factors as influenced by tillage. Field experiments were initiated in southern Illinois in the spring of 2013 and 2014 on fields infested with waterhemp and Palmer amaranth at the Southern Illinois University Belleville Research Center. Two tillage treatments (tillage planned for May 1st, and tillage planned for June 1st) and a control (no-tillage) were evaluated. *Amaranthus* seedlings were identified and enumerated in the center 1-m^2 quadrat every seven days from April through November or first frost. All weed seedlings were removed following each enumeration. Soil temperature and moisture were recorded hourly throughout the experiment using data loggers. Waterhemp emerged earlier in the season than did Palmer amaranth. In 2013 the initial emergence of waterhemp and Palmer amaranth was observed the first and second week of May, respectively, regardless of tillage. In 2014 initial waterhemp emergence was two weeks earlier than 2013 while Palmer amaranth's initial emergence was similar to the previous year. Palmer amaranth emerged over a longer period of time compared to waterhemp. By the end of June, 90% of the waterhemp had emerged regardless of tillage or year. The time for Palmer amaranth to reach 90% cumulative emergence was extended to the third week of July and the second week of August in 2013 and 2014, respectively. Spikes in soil moisture (weekly highs) were the single best predictor of Palmer amaranth emergence followed by soil temperature. For waterhemp the single best predictor for emergence was soil temperature (weekly highs and lows) followed by soil moisture. Highest soil temperatures and lowest soil moisture were observed immediately after tillage and were correlated to low emergence of Palmer amaranth and waterhemp, but only until the next rainfall event. In 2013 spikes in soil moisture observed 11 days prior and weekly high soil temperatures 2 weeks prior to emergence were positively and negatively correlated, respectively to Palmer amaranth emergence (R^2 = 0.30). In 2014 spikes in soil moisture observed 2 weeks prior and weekly high soil temperatures 8 days prior to emergence were the best predictors of Palmer amaranth emergence (R^2 = 0.37). In 2013 waterhemp emergence was initially positively and later negatively correlated to maximum soil temperature 13 days prior to emergence, with temperatures above 30 C correlated to lower emergence (R^2 =0.35). In 2014, waterhemp emerged in April and had a positive correlation to high soil temperatures 10 days prior followed by a positive correlation to minimum soil temperatures 8 days prior emergence later in the season (R^2 =0.55). The pattern of emergence for waterhemp was more correlated to high soil temperatures in the spring and to low soil temperatures throughout the summer in both years. Conversely, high soil moisture associated with adequate soil temperature had a greater correlation to the emergence pattern of Palmer amaranth. Monitoring soil moisture and temperature may assist in Palmer amaranth and waterhemp management in terms of field scouting or implementing control measures.

SEED-BANK DEPLETION AND EMERGENCE PATTERNS OF GIANT RAGWEED IN VARIOUS CROP ROTATIONS. Jared J. Goplen*[1], Jeffrey L. Gunsolus[2], Craig C. Sheaffer[2], Roger L. Becker[2], Jeffrey A. Coulter[2], Fritz Breitenbach[2], Lisa Behnken[2], Gregg A. Johnson[2]; [1]University of Minnesota, Saint Paul, MN, [2]University of Minnesota, St. Paul, MN (120)

In Minnesota, biotypes of giant ragweed (*Ambrosia trifida*) resistant to multiple herbicide sites of action have been identified. Biotypes resistant to multiple herbicides reduces the number of effective herbicides for a given crop and necessitates the development of alternative weed control strategies. From 2012-2014 in southern Minnesota, we determined the effect of six crop rotations containing corn (C), soybean (S), alfalfa (A), and wheat (W): (i.e. CCC, SCC, CSC, SWC, SAC, AAC) on giant ragweed seed-bank depletion and emergence patterns. The giant ragweed seed-bank was highly depleted over the course of the study, regardless of crop rotation, with 97% of the seed-bank being depleted over 2 years when seed inputs back into the seed-bank are eliminated. Giant ragweed emergence across all treatments was highly variable among years due to the overall depletion of the seed bank along with the influence of variable soil temperature and moisture, with 11.4, 58.4, and 3.9 seedlings m^{-2} yr^{-1} emerging in 2012, 2013, and 2014, respectively. Across all treatments, 95% of total giant ragweed emerged by June 3rd and June 15th in 2013 and 2014, respectively. Wheat and alfalfa, which were established early in the growing season in 2013, had lower giant ragweed emergence than later-planted corn and soybean. Cumulative giant ragweed populations in 2013 were 93.3, 61.5, 42.7, 39.8, and 19.7 seedlings m^{-2} in corn, soybean, wheat, seedling alfalfa, and established alfalfa, respectfully. The low level of emergence in wheat, seedling alfalfa, and established alfalfa is likely due to early season soil conditions being less conducive to giant ragweed emergence. Two years of alfalfa (AAC) also provided conditions most favorable for seed degradation, as a high level of seed-bank depletion (99%) was observed alongside lower overall levels of emergence. The cutting schedule associated with alfalfa production also makes it easier to implement a zero threshold to prevent giant ragweed from going to seed, since weeds are cut multiple times in a growing season. These results show that herbicide-resistant giant ragweed infested fields can be managed by utilizing various crop rotations in addition to strategic timings of mechanical and chemical weed control options, which can be part of an integrated weed management plan directly targeting early emerging weeds.

BIOLOGICAL RESPONSE OF FOREIGN PALMER AMARANTH (*AMARANTHUS PALMERI*) BIOTYPES IN INDIANA. Douglas J. Spaunhorst*, William G. Johnson; Purdue, West Lafayette, IN (121)

In 2013 and 2014 Palmer amaranth (*Amaranthus palmeri*) populations from Arkansas, Indiana, Mississippi, Missouri, and Nebraska were established in a common garden experiment at Throckmorton Purdue Agricultural Center near Lafayette, Indiana. The purpose of this study was to evaluate the influence of planting date, growth, and above ground biomass of these biotypes. Approximately 0.3 g of Palmer amaranth seed from each respective population were planted in plots measuring 7.6 m^{-1} in length in 3 rows spaced 40 cm apart on 3 different dates. The first planting occurred at 457 and 425 growing degree day's (GDD's), the second at 637 and 634 GDD's, and the third at 1529 and 1524 GDD's in 2013 and 2014, respectively. Results from this study suggest late-season (1525 GDD's) emerging Palmer amaranth grew more rapidly than plants emerging early-season (441 GDD's). When pooled across planting date, the Arkansas population was the smallest at 1000 and 1250 GDD's after planting. At 1250 GDD's after planting, the Nebraska and Mississippi populations measured 38 and 27 cm taller than the Arkansas population. Few differences in plant biomass were reported. In 2013 the Mississippi population's dry weight was greater than the Nebraska population. However in 2014, the Missouri, Mississippi, and Nebraska populations produced similar amounts of biomass and weighed more than the Indiana population. This study indicates that Palmer amaranth growth can vary between populations and timing of plant emergence. Also, late-season emerging plants can approach the maximum weed height for herbicide application before early-season emerging plants.

SEED PRODUCTION OF COMMON WATERHEMP (*AMARANTHUS RUDIS*) IS AFFECTED BY TIME OF EMERGENCE. Heidi R. Davis*, Reid Smeda; University of Missouri, Columbia, MO (122)

High seed production is a contributing factor to common waterhemp (*Amaranthus* rudis) becoming a major weed infesting Midwest crop production systems. Waterhemp continually emerges from spring to summer, and female plants of this dioecious species produce seeds that add to the soil seed bank. Little is known about the partition of plant energy to leaves and stems versus seeds in relationship to emergence date. At a research farm in central MO, waterhemp seedlings were allowed to emerge from the existing soil seed bank at five defined emergence timings from mid-May through mid-September. Weekly through plant senescence, the heights and number of nodes were recorded from six plants in each of five replications. As plants initiated flowering, up to 55 plants across the trial at each emergence date were observed to assess the ratio of male to female plants. For 2013 and 2014, 47 to 62% and 43 to 55% of the population were female plants, respectively. When greater than 80% of the seed were determined visually to be mature, six plants from each of the five replications for each emergence date were harvested and dry weight recorded. Seeds were extracted from plants to determine seed production. For 2013, plants emerging in mid-May produced an average of 803,402 seeds, whereas plants emerging in late July only produced an average of 46,562 seeds. In 2014, seed production for plants emerging mid-May and late July was 405,186 and 179,576 seeds, respectively. For 2014 plants, as a percentage of overall plant weight, seed weight per plant increased from 8 to 22% from mid-May to late July. No seeds were counted on plants emerging in September 2013 (about 6 weeks before an expected frost), however September emerging plants in 2014 produced an average of 14 seeds. In 2013, plants emerging from mid-May to early June had similar average number of seeds perkilogram of seed weight; 4,832,955 and 4,830,338 seeds, respectively. For plants emerging in late June and late July, an average of 4,482,330 and 3,817,685 seeds per kilogram of seed weights, respectively were produced. However plant energy allocated to seed weight was different in 2014; plants emerging mid-May and late July produced 8,001,917 and 3,793,128 seeds per kilogram of seed weights, respectively. For early season emerging waterhemp, more of the plants energy appears allocated to leaf and stem production. Comparatively, later season emerging plants allocate more energy toward seed production. Growers must consider that early season emerging waterhemp may be more competitive with annual crops than later season emerging plants, but later season plants likely make significant contributions to the soil seed bank.

GROWTH RESPONSE OF GLYPHOSATE-RESISTANT GIANT RAGWEED (*AMBROSIA TRIFIDA*) TO WATER STRESS. Simranpreet Kaur*[1], Jatinder S. Aulakh[2], Amit J. Jhala[3]; [1]University of Nebraska Lincoln, Lincoln, NE, [2]University of Nebraska- Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (123)

Glyphosate-resistant giant ragweed is an economically important weed of eastern and mid-western corn and soybean belt. Drought conditions can result in water deficit that may hinder giant ragweed growth and reproduction. Scientific literature is not available about response of giant ragweed to water stress. The objectives of this study were to determine the effects of degree and duration of water stress on growth and seed production of glyphosate-resistant giant ragweed. Experiments were conducted under greenhouse conditions and a four parameter log-logistic model was used to regress giant ragweed plant height, number of leaves, chlorophyll index, and growth index. The experiment for degree of water stress included response of giant ragweed to 100, 75, 50, 25, and 12.5% of field capacity. Giant ragweed plants watered at 75% field capacity achieved maximum height (140-cm), leaf number (58), and growth index (588 cm^3), though no significant difference was observed in plant height and leaf number at ≥50% field capacity. Root and shoot biomass was reduced 46 to 96% at ≤50% field capacity levels compared to 100% field capacity. Plants receiving degree of water stress at 12.5% field capacity produced up to 7 seeds $plant^{-1}$, whereas plants maintained at 100% field capacity produced 98 seeds $plant^{-1}$. The experiment for duration of water stress included response of giant ragweed to 2, 4, 6, 8, and 10 d of water stress interval. Results suggest that >4 d of water stress interval reduced giant ragweed plant height ≥20%, root and shoot biomass ≥66%, leaf number ≥36%, and growth index ≥54%, and seed production by 36% compared with 2 d of water stress interval. The chlorophyll index varied from 29 to 36% and was not affected by degree or duration of water stress. Results from this study indicate reduction in giant ragweed growth and fecundity at <50% field capacity or water stress intervals >4 d.

COVER CROPS IN EDAMAME: BALANCING CROP EMERGENCE WITH WEED SUPPRESSION. Laura E. Crawford*[1], Martin M. Williams II[2], Samuel E. Wortman[1]; [1]University of Illinois, Urbana, IL, [2]USDA-ARS, Urbana, IL (124)

The vegetable processing industry cites weed interference as a major hurdle limiting edamame (*Glycine max*) production in the U.S., in part because few herbicides are registered for use on the crop. Certain cover crops can reduce weed density and growth; however, their role in edamame is unknown, particularly since crop emergence is often poor. The objective of this study was to identify cover crop residue management systems that favor edamame emergence and growth. Twelve edamame cultivars were no-till planted into five different cover crop treatments: winter-killed Daikon radish (*Raphanus sativus*), early-killed (April 17) canola (*Brassica napus*), late-killed (May 5) canola, early-killed rye (*Secale cereale*), and late-killed rye. At the time of edamame planting, cover crop residues ranged from 108 g/m^2 in the winter-killed radish treatment to 1,439 g/m^2 in the late-killed rye treatment. There was a significant effect of cover crop treatment ($p < 0.0001$) and of edamame cultivar ($p <0.0001$) on crop emergence, but no interaction was observed ($p = 0.9112$). Interestingly, edamame emergence was improved in the radish and canola treatments, relative to the bare soil control. In contrast, cover crop treatment did not affect mid-season biomass ($p = 0.2913$) or density ($p = 0.1787$) of naturally occurring weeds, including pigweeds (*Amaranthus spp*.), common purslane (*Portulaca oleracea*), common lambsquarters (*Chenopodium album*), and velvetleaf (*Abutilon theophrasti*). Preliminary results suggest certain cover crops can be managed in a way that does not harm edamame emergence and improves crop establishment.

CEREAL RYE COVER CROP EFFECTS ON COMMON WATERHEMP AND COMMON LAMBSQUARTERS EMERGENCE. Meaghan Anderson*, Robert Hartzler; Iowa State University, Ames, IA (125)

Experiments were conducted to determine whether cereal rye (*Secale cereale*) suppresses emergence of two important weeds. Rye was seeded in September and October at different densities and chemically terminated. The plots were seeded with either common waterhemp (*Amaranthus rudis*) or common lambsquarters (*Chenopodium album*) following the October rye seeding date. Cereal rye was terminated in early May at Feeke's stage 8-9, and weed emergence was determined approximately every seven days following initial emergence of the species. Cereal rye seeding date had a greater effect on biomass accumulation and percent cover than seeding rate, with approximately 3000 kg ha^{-1} biomass with

September seedings and 400 kg ha^{-1} with October seedings. Common waterhemp emergence was equal to or increased compared to the control in the presence of cereal rye residue in both 2013 and 2014. Common lambsquarters emergence was increased by two cereal rye biomass treatments in 2014 but was otherwise unaffected by the presence of cereal rye biomass. Cereal rye residue from the September rye seeding date increased the time to 10% and 50% emergence of common waterhemp in 2013 by at least nine days. In 2014, the time to 10% emergence was increased by approximately 20 days and time to 50% emergence was increased by more than 10 days compared to the control. Common lambsquarters time to 10% and 50% emergence were unaffected in 2013, but the time to 50% emergence was increased 13 to 40 days in the September rye seeding date compared to the control in 2014.

EFFECT OF INOCULUM CONCENTRATION OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS* ON INFECTION OF ALTERNATIVE HOSTS. Taylor M. Campbell*[1], Joseph T. Ikley[1], William G. Johnson[2], Kiersten A. Wise[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (126)

Goss's bacterial wilt and leaf blight of corn is a bacterial disease caused by *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). It was first discovered in 1969 in Dawson county, Nebraska. The disease has since spread to most of the Midwest and was confirmed in Indiana in 2008. Along with corn, other grass species have been confirmed to be hosts of Goss's wilt. Alternative weed hosts include green foxtail (*Setaria viridis*), giant foxtail (*Setaria faberi*), yellow foxtail (*Setaria pumila*), bristly foxtail (*Setaria verticillata*), shattercane (*Sorghum bicolor*), large crabgrass (*Digitaria sanguinalis*), and johnsongrass (*Sorghum halepense*). The cover crop annual ryegrass (*Lolium multiflorum*) is also a reported host. Previous studies have evaluated inoculum concentrations on corn (*Zea mays*) from 1 x 10^1 to 1 x 10^8 colony forming units (CFU) per ml. The objectives of this greenhouse experiment were to (1) determine the lowest inoculum concentration required to cause infection in alternative hosts, (2) observe how time influences the disease severity of Cmn in hosts, and (3) investigate the susceptibility of different host plants to Cmn. The species tested were giant foxtail, johnsongrass, annual ryegrass, a tolerant corn hybrid and a susceptible corn hybrid. Two leaves were inoculated per plant. Each leaf received one of two different inoculation techniques. Host plants were inoculated with bacterial suspensions containing 1 x 10^1 through 1 x 10^7 CFU of Cmn per ml. After inoculation, plants were rated every three days for 21 days. Length of lesion formed and a visual rating of percent of leaf with symptomatic tissue were measured. The susceptible corn hybrid showed greater disease severity compared to other hosts observed. Plants inoculated with the lowest inoculum concentration level took six more days to develop symptoms compared to the highest inoculum concentration. This study reveals that corn has the potential to contribute more to Cmn inoculum levels than alternative hosts and that lower inoculum concentrations of Cmn will delay the onset of symptoms observed in host plants.

HERBICIDE CARRYOVER EVALUATION IN COVER CROPS FOLLOWING SILAGE CORN AND SOYBEAN HERBICIDES. Daniel H. Smith*, Elizabeth J. Bosak, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (127)

Cover crops are a growing interest for corn and soybean producers in the North Central region due to the benefits of reducing soil erosion, providing and scavenging nutrients, and increasing soil organic matter. This study was conducted to determine whether common soil applied herbicides with residual weed control properties applied in the spring during the establishment of corn and soybean crops affect the subsequent establishment of cover crops in the fall. Corn and soybean trials with glyphosate-resistant cultivars were established at Arlington Agricultural Research Station, Arlington, WI on June 2, 2013 and May 28, 2014. Similar trials were also conducted near Lafayette, IN but only the Arlington, WI data are shown. Corn and soybean trials had fourteen herbicide treatments applied at common labeled rates and timings. Treatments were replicated four times. Each crop included a control treatment with no residual herbicide applied, but weeds were managed with postemergence (POST) glyphosate for all treatments as needed to remove any effects from weeds. Both trials were harvested for silage near the beginning of September, and seven different cover crop species and/or varieties were seeded uniformly across all herbicide treatments. The cover crops included Tillage Radish® (*Raphanus* sp;), crimson clover (*Trifolium incarnatum*), 'Guardian' winter rye (*Secale cereal*), a mixture of 70% oat (*Avena sativa*) plus 30% peas (*Pisum sativum)*, and three different annual ryegrass (*Lolium multifloram*) varieties. The annual ryegrass varieties included 'Bruiser' and 'King', both diploids, and a tetraploid. Nearly two months after seeding, the cover crops were evaluated for herbicide injury with digital image analysis for percent cover and by weighing total dried biomass collected from a 0.25m^2 quadrat. Herbicide injury included the evaluation of plant stunting and loss of plant greenness. In 2013 winter rye was the only cover crop without growth inhibition because of herbicide treatments applied in the corn or soybean trials (both p-values < 0.0001). All other cover crops had significantly reduced biomass ($P < 0.05$) and percent cover ($P < 0.05$) for at least one of the residual herbicide treatments applied in the corn and soybean trial. In 2014 'King' and the tetraploid annual ryegrass were the only cover crops that had growth inhibition because of herbicide treatments applied in the corn or soybean trials (both p-values <0.0001). All other cover crops did not have significantly reduced percent cover ($P<0.05$) for all of the residual herbicide treatments. From these results we suggest several commonly used corn and soybean herbicides have the potential to adversely affect the establishment of many different cover crops, but the severity of damage will be determined by weather, cover crop species, and the specific herbicide combination. More research will be needed to establish best management practices for farmers interested in the use of cover crops following silage harvest.

MECHANISM OF RESISTANCE IN 2,4-D-RESISTANT WATERHEMP. Lacy J. Leibhart*[1], Amar S. Godar[2], Mithila Jugulam[2], Zac J. Reicher[1], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (128)

While the mode-of-action of auxinic herbicides has been extensively studied, the primary biochemical site of action remains relatively unknown. Laboratory studies were conducted on common waterhemp populations that were confirmed as resistant and susceptible to the auxinic herbicide 2,4-dichlorophenoxy acetic acid (2,4-D) to determine absorption, translocation, and metabolism of the herbicide. For absorption and translocation studies, seedlings were treated with ^{14}C-labeled 2,4-D, harvested at 6, 24, 48 and 72 hours after treatment (HAT) and separated into treated leaf (TL), stem and leaf tissue above treated leaf (ATL), steam and leaf tissue below treated leaf (BTL), and below ground root tissue (BG). Radioactivity was quantified in each plant part. For metabolism studies, seedlings were treated ^{14}C-labelled 2,4-D and harvested 24, 48 and 72 HAT. Whole plant tissue was homogenized, centrifuged and total radioactivity determined with reverse-phase HPLC. Resistant and susceptible plants absorbed 49% and 51% and translocated 24.5% and 28.9%, respectively, of the herbicide. Plant parts ATL and BG contained the same amount of radioactivity for both populations, but BTL contained 1.9% and 3.3% radioactivity in resistant and susceptible populations, respectively. Due to the similar amounts of radioactivity absorbed and translocated in both resistant and susceptible populations, we concluded that neither were a factor in the mechanism of resistance of 2,4-D in common waterhemp. In metabolism studies, at 24, 48, and 72 HAT, susceptible plants contained 84%, 57%, and 50%, respectively, of the parent compound 2,4-D while resistant plants contained less with just 48%, 30%, and 38%, respectively. We conclude that metabolism is a contributing factor in the mechanism of resistance of 2,4-D in common waterhemp.

DISTRIBUTION OF GLYPHOSATE-RESISTANT KOCHIA IN SOUTH-WESTERN NEBRASKA. Spencer L. Sameulson*[1], Bruno Canella Vieira[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (129)

Kochia (*Kochia scoparia*) has been reported as having resistance to glyphosate as well as other different herbicide modes-of-action. In south-western Nebraska, kochia has become very problematic for growers to manage. The objective of this study was to evaluate distribution and frequency of glyphosate-resistant kochia in south-western Nebraska. Collections of kochia populations were made by traveling the south-western region of the state and collecting up to 20 plants from fields that had kochia escapes. Greater emphasis was made in finding fields that had large populations that were not just along the edge of the field or road sides, but that were in the middle of the field with the crop. At the time the population was collected, the GPS coordinates and in-field agronomic practices were recorded. Mature plants were harvested and seeds were separated from the plant and stored at 0 C until the commencement of the greenhouse testing. Seeds were germinated in the greenhouse and treated with glyphosate at one of the following rates: 0, 265, 530, 1061, 2122, 4244, and 8488 g ae/ha when plants were 10-15 cm tall. Visual estimates of injury were collected on a scale of 0-100 (0 being no effect from herbicide and 100 being complete control). Visual estimates of injury were recorded at 28 days after treatment (DAT). Surviving plants were harvested and weighed to determine fresh and dry weight biomass accumulation. Resistance was observed in populations in Chase, Lincoln, Hayes, Gosper, Red Willow, and Dawson counties. Some populations had I_{50} values of over 3,000 g/ha. This survey is helpful in mapping the location of resistant populations in south-western Nebraska.

DISTRIBUTION OF GLYPHOSATE-RESISTANT PALMER AMARANTH IN SOUTH-WESTERN NEBRASKA. Bruno Canella Vieira*[1], Spencer L. Sameulson[1], Chandra J. Hawley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (130)

Palmer amaranth (*Amaranthus palmeri* S. Wats.), a member of Amaranthaceae family, is considered a highly competitive weed that causes significant yield loss at relatively low densities and can produce large amounts of seed, facilitating its dissemination. Palmer amaranth has a dioecious reproduction and has a high level of genetic variation that facilitates its environmental adaptation. Several Palmer amaranth populations have been reported resistant to different herbicide modes-of-action, such as ALS-inhibitors, microtubule inhibitors, PSII-inhibitors, EPSP and HPPD-inhibitors. The first report of glyphosate-resistant Palmer amaranth occurred in 2005 in Georgia. The aim of this study was to investigate the response of Palmer amaranth populations from south-western Nebraska to glyphosate. A total of 83 Palmer amaranth populations were collected among south-western Nebraska and seedlings germinated in the greenhouse from those populations were subjected to a glyphosate-dose response study. Plants were sprayed with one of 0, 265, 531, 1061, 2122, 4244 or 8489 g ae ha^{-1} of glyphosate. Visual injury estimations (%) were measured 28 days after treatment (DAT) and data were analyzed using a non-linear regression model with drc package in R 3.1.2. I_{50} values were estimated using a four parameter log-logistic equation: y = c + (d –c / 1 + exp (b (log x –log e))). Resistance ratios were calculated by dividing the I_{50} of each population by the I_{50} value of the most sensitive population. The study results showed a 19.8 fold difference in the I_{50} resistance ratio between the most and the least sensitive populations. The population Red Willow County 1 was the most sensitive population showing an I_{50} of 98.9 g ai ha^{-1}. The population Lincoln County 1 was the least sensitive population showing an I_{50} estimation of 1962.4 g ai ha^{-1}. The Lincoln County 1 population and others show that there is glyphosate-resistant Palmer amaranth populations in south-western Nebraska. Thus, monitoring the I_{50} shift is an important part of the integrated weed management (IWM) and a key factor for the successful control of glyphosate-resistant Palmer amaranth in south-western Nebraska. Furthermore, more aggressive and complex management of Palmer amaranth is needed in Nebraska.

GLYPHOSATE RESISTANCE IN PALMER AMARANTH IN KANSAS: WHAT DO WE KNOW NOW? Amar S. Godar*[1], Dallas E. Peterson[1], Phillip W. Stahlman[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (131)

No abstract submitted

GENETICS AND INHERITANCE OF NON-TARGET-SITE RESISTANCES TO ATRAZINE AND MESOTRIONE IN AN ILLINOIS WATERHEMP POPULATION. Janel L. Huffman*[1], Nicholas E. Hausman[2], Aaron G. Hager[2], Dean E. Riechers[2], Patrick J. Tranel[2]; [1]University of Illinois, Champaign/Urbana, IL, [2]University of Illinois, Urbana, IL (132)

A population (designated MCR) of waterhemp (*Amaranthus tuberculatus*) from McClean County, Illinois is resistant to both mesotrione and atrazine by elevated rates of herbicide metabolism. In this study, the genetics and inheritance of both mesotrione and atrazine in the MCR waterhemp population were studied. Resistant and sensitive plants were crossed to obtain reciprocal F_1 lines, which were used in subsequent crosses to create pseudo F_2 and backcross (to sensitive parent; BC_s) lines. Dose response studies with F_1 lines showed that both mesotrione and atrazine resistance were inherited as nuclear, incompletely dominant traits. Segregation ratios of atrazine and mesotrione resistances were determined in the BC_s and F_2 populations in separate experiments using single-rate herbicide screens. In the case of atrazine, a dose was selected that controlled the sensitive parent but not the F_1 or resistant parent. At this dose, BC_s and F_2 lines segregated 1:1 and 1:3, respectively, for susceptibility(S): resistance (R), consistent with single gene inheritance. For mesotrione, it was more difficult to select a discriminatory herbicide dose for two reasons: the magnitude of resistance is relatively low, and the F_1 plants were not uniform in their resistance levels. The observation of segregation within the F_1 lines suggested that mesotrione resistance is multigenic and the parents used in the cross were not homozygous at the resistance loci. Several single-rate screens were conducted on BC_s and F_2 lines with various mesotrione doses, and expected segregation ratios for different gene models were corrected based on responses of parental and F_1 controls. At low mesotrione doses, more F_2 plants survived than expected based on a single gene trait whereas, at high doses, fewer F_2 plants survived than expected. Dry weight data were obtained from some of the single rate screens, and these data confirmed the conclusions obtained from survival data. Specifically, atrazine response segregated into two discreet classes (R and S) in both the F_2 and BC_S lines, consistent with single gene inheritance, whereas mesotrione response showed a continuous distribution of phenotypes in segregating lines, indicating multigenic inheritance. We conclude that metabolism-based atrazine resistance in the MCR population is conferred by a single major gene while mesotrione resistance in this population is complex and likely mediated by two or more major genes.

EVALUATION OF CYTOCHROME P450 EXPRESSION IN MESOTRIONE-RESISTANT AND -SENSITIVE WATERHEMP (*AMARANTHUS TUBERCULATUS*) POPULATIONS. Rong Ma*[1], Kris N. Lambert[2], Dean E. Riechers[3]; [1]UIUC, Urbana, IL, [2]University of Illinois Champaign-Urbana, Urbana, IL, [3]University of Illinois, Urbana, IL (133)

Waterhemp (*Amaranthus tuberculatus*) is a troublesome annual weed species in maize (*Zea mays*), soybean (*Glycine max*), and cotton (*Gossypium hirsatum*) production, in part due to multiple mechanisms for herbicide resistance. Our previous research reported the first case of resistance to 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides in a waterhemp population designated MCR (for McLean County, Illinois HPPD-Resistant). Elevated rates of metabolic detoxification via cytochrome P450 monooxygenase (P450) activities contribute significantly to mesotrione resistance within the MCR population. Greenhouse and laboratory experiments were conducted to test the hypothesis that higher expression levels of specific P450(s) correlate with mesotrione resistance in the MCR population. A mesotrione-sensitive population, WCS (for Wayne County, Illinois herbicide-sensitive) and several other HPPD-sensitive waterhemp populations were used for comparison with MCR. Meristem and new leaf tissue from individual waterhemp plants of the same ages and height (10-cm) were used for RNA extraction and quantitative reverse-transcriptase PCR (qRT-PCR) to compare transcript levels of candidate P450 genes among populations. Primers were designed from conserved regions between the cDNAs of maize *Nsf1* and the most similar P450 contigs in a waterhemp transcriptome database. Maize *Nsf1* was chosen as a candidate P450 because the Nsf1 enzyme significantly contributes to multiple-herbicide tolerance in maize. qRT-PCR demonstrated that a P450 transcript most similar to maize *Nsf1* (named *ArNsf1*) is more highly expressed in meristem tissue of MCR seedlings (10-cm) compared with each HPPD-sensitive population. Significant differences in expression were not detected when comparing two additional candidate P450s among these waterhemp populations. *ArNsf1* expression in MCR seedlings harvested at 4, 6, 8, and 10-cm was significantly higher than in WCS seedlings, but not in 2-cm seedlings. Therefore, only *ArNsf1* expression correlated with mesotrione POST resistance in MCR, and growth-stage results suggested that *ArNsf1* expression may be developmentally regulated. Currently, research is being conducted with additional P450 genes to determine if their expression correlates with mesotrione resistance, and obtain and compare the entire cDNA sequences of *ArNsf1* in MCR and WCS.

PHYSIOLOGICAL AND MOLECULAR CHARACTERIZATION OF MESOTRIONE RESISTANCE IN PALMER AMARANTH (*AMARANTHUS PALMERI*) FROM KANSAS. Sridevi Betha*, Amar S. Godar, Curtis R. Thompson, Dallas E. Peterson, Mithila Jugulam; Kansas State University, Manhattan, KS (134)

Palmer amaranth is an economically important weed in corn, grain sorghum, cotton, soybean, and alfalfa production in Kansas and much of the United States. Mesotrione and atrazine are used as pre- as well as post-emergence herbicides to control broadleaved weeds including Palmer amaranth. However, due to extensive genetic variability and intense selection pressure, Palmer amaranth has evolved resistance to multiple herbicides including hydroxyphenylpyruvate dioxygenase (HPPD) inhibitors such as mesotrione. The objective of this study was to characterize the physiological and molecular basis of resistance to mesotrione in Palmer amaranth. Mesotrione dose response assay was conducted to determine the level of resistance in a Palmer amaranth population from Kansas (G2A) using a mesotrione-susceptible population from Mississippi (Azlin) as a control. Absorption, translocation and metabolism of ^{14}C-mesotrione and gene expression of the target enzyme (HPPD) were investigated. Ten-12 cm tall Palmer amaranth plants were treated with ^{14}C-mesotrione (3.3 kBq) and harvested at 48 and 72 hours after treatment (HAT) to evaluate absorption and translocation. Similarly, plants were treated with ^{14}C-mesotrione (6.67 kBq) to determine metabolism of mesotrione at 4, 8, 16, 24, 48 and 72 HAT. HPPD gene expression was examined by extracting RNA and cDNA synthesis followed by quantitative PCR (qPCR). The dose-response results suggest that the G2A plants were about ten-fold more resistant to mesotrione than Azlin (R/S: 11.55). No significant differences were observed in ^{14}C-mesotrione uptake/translocation or metabolism between G2A and Azlin at 48 and 72 HAT. However, at 16 and 24 HAT, mesotrione was metabolized to polar compounds more rapidly in G2A than Azlin. Furthermore, at 24 HAT, only 1.5% of parent compound (^{14}C-mesotrione) remained in G2A as compared to 19.4% in Azlin. More importantly, we found at least 10 fold increase in the HPPD gene expression in G2A compared to Azlin. This is the first report demonstrating mesotrione resistance in Palmer amaranth mediated by two different mechanisms, i.e. increased target gene expression coupled with rapid metabolism of mesotrione, likely mediated by cytochrome P450s.

RELATIONSHIP BETWEEN *EPSPS* COPIES, EXPRESSION, AND LEVEL OF RESISTANCE TO GLYPHOSATE IN COMMON WATERHEMP (*AMARANTHUS RUDIS*) FROM KANSAS. Andrew J. Dillon*, Vijay K. Varanasi, Dallas E. Peterson, Mithila Jugulam; Kansas State University, Manhattan, KS (135)

Common waterhemp (*Amaranthus rudis*) is a troublesome weed in Kansas cropping systems. Recently, populations of common waterhemp from Kansas, resistant to the non-selective herbicide glyphosate which targets 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), were characterized. Resistance in these plants was found to have evolved as a result of *EPSPS* gene amplification. The goals of this study were: a) to determine the relationship between *EPSPS* gene copies and *EPSPS* gene expression and b) to investigate genomic organization of the amplified EPSPS copies using fluorescent in situ hybridization (FISH) in three confirmed glyphosate-resistant *A. rudis* populations. Plants from these populations were screened with glyphosate and in the survivors, *EPSPS* gene copies as well as expression relative to acetolactate synthase (*ALS*) gene were determined by a quantitative polymerase chain reaction (qPCR). FISH was performed using common waterhemp *EPSPS* probes. Furthermore, shikimate accumulation was also determined in these glyphosate-resistant plants. Results of these experiments indicate a positive correlation between *EPSPS* copies, expression, and level of glyphosate resistance. As expected, a negative correlation between shikimate accumulation and *EPSPS* copies was found. Sequencing of the *EPSPS* gene showed no presence of the proline 106 mutation, which is known to be associated with glyphosate resistance. FISH analysis of resistant plants illustrated presence of amplified *EPSPS* copies on two homologous chromosomes, likely near the centromeric region. This is the first report demonstrating a positive relationship between *EPSPS* copies and expressions, as well as chromosome configuration of *EPSPS* copies in glyphosate resistant common waterhemp from Kansas.

SYNERGISTIC ANTAGONISM: CHARACTERIZING THE INTERACTION OF PARAQUAT AND METRIBUZIN ON HORSEWEED. Garth W. Duncan*[1], Julie M. Young[1], Bryan Young[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, W. Lafayette, IN (136)

Control of horseweed in burndown applications has been one of the most widespread challenges in no-till soybean production. Effective herbicide options are limited to control glyphosate-resistant and ALS-resistant horseweed in Indiana. However, the use of paraquat applied alone has resulted in inconsistent levels of control. The addition of metribuzin to paraquat has proven to be a more effective burndown option for growers providing greater efficacy and consistency. However, the interaction of paraquat (photosystem I electron diverter) with metribuzin (photosystem II inhibitor) applied in combination has never been the subject of any in-depth research. Therefore, experiments were conducted to elucidate the interaction of paraquat with metribuzin on horseweed as influenced by application time of day. In the field, treatments included four rates of paraquat (0, 280, 560, and 1120 g ai ha^{-1}), metribuzin (0, 70, 140, and 280 g ai ha^{-1}), and their respective combinations were applied at two application times throughout the day (1:45 pm or 8:00 pm). Additionally, four plants were marked at two different height ranges (6 to 10 cm and 15 to 20 cm) within each plot. Visual estimates of control were recorded at 1, 3, 7, 14, and 28 days after treatment (DAT). Marked plants were harvested at 28 DAT for dry weight determination. A greenhouse experiment using paraquat (0, 8.25, 17.5, 35, and 70 g ha^{-1}), metribuzin (70 and 210 g ha^{-1}), and their combinations was used to confirm the observations recorded in the field. Horseweed were grown under a 16hr photoperiod and herbicide treatments applied at 7:30 am when plants were 8 to 9 cm in diameter. Visual estimates of control were taken at 6, 12, 24, 48, 72 hours after treatment and 7, 14, 21 days after treatment. Plants were harvested at 21 DAT for dry weight determination. In the field, combining metribuzin with paraquat reduced control of horseweed at 24 hrs after treatment as compared to paraquat alone at both application times of day and weed heights. Additionally, greater efficacy was achieved with the paraquat and metribuzin combination at the 8:00 pm application timing compared to the 1:45 pm application timing. At 3 DAT, control was similar from paraquat applied alone and in combination with metribuzin. However, by 28 DAT, synergy was observed in the 15 to 20 cm plants with the combination of paraquat and metribuzin at the 1:45 application timing as compared to paraquat alone. Efficacy by paraquat applied alone at the 8:00 pm timing was not improved by the addition of metribuzin. Greenhouse experiments confirmed field observations that paraquat alone displayed leaf necrosis on horseweed faster (necrosis by 12 hours after treatment) than the combination of paraquat + metribuzin (necrosis by 48 hours after treatment). However, by 72 hours after treatment, control of horseweed was greater from the combination than paraquat alone. Therefore, an initial loss of herbicide efficacy was followed by greater final herbicide efficacy for the combination of paraquat plus metribuzin compared with paraquat applied alone. In theory, metribuzin may be disrupting electron flow into PS I which may initially reduce paraquat activity. This may allow for greater foliar absorption and localized movement of the herbicides that ultimately results in greater herbicide efficacy. This theory will be the subject of future research for this herbicide combination.

2,4-D METABOLISM IN ENLIST™ CROPS. Joshua J. Skelton*[1], David M. Simpson[2], Mark A. Peterson[3], Dean E. Riechers[4]; [1]University of Illinois, Champaign, IL, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Indianapolis, IL, [4]University of Illinois, Urbana, IL (137)

The Enlist™ Weed Control System provides a new, novel means of conferring 2,4-D tolerance to several crops including soybean and corn. Enlist Duo™ herbicide is a premix of 2,4-D choline and glyphosate for use in Enlist™ crops. Insertion of the *aad-12* gene in soybeans and *aad-1* gene into corn, which encode bacterial aryloxyalkanoate dioxygenase (AAD) enzymes, provides rapid metabolism of 2,4-D to dichlorophenol. Much is known about the AAD enzymes and its catalyzed reaction, but less has been reported on 2,4-D metabolism in Enlist crops and non-transformed (NT) crop varieties. Previous research has reported necrotic spots on leaves at top of canopy when elevated rates of Enlist Duo are applied but new leaves emerged with no necrosis and temporary injury did not affect grain yield. To gain insight into metabolism of 2,4-D in Enlist soybean and corn relative to NT varieties, an excised-leaf growth chamber assay utilizing [URL-^{14}C]-2,4-D was conducted in 2013 and 2014. In previous studies, a whole-plant assay was used to determine 2,4-D metabolism, but necrotic spots, similar to necrosis observed in field trials, formed where the droplets of the herbicide solutions were applied to the leaf surface. To eliminate the potential impact of injury on 2,4-D metabolism, an excised-leaf assay was developed to measure metabolism without injuring the crop. Soybean and corn leaves were removed from the plant and placed in Eppendorf tubes containing 100 µL of a herbicide solution containing 20 µM ^{14}C-2,4-D (spec. act. 37 mCi/mMol) to absorb the herbicide through the petiole (soybean) or leaf (corn). In soybeans, the addition of non-radiolabeled glyphosate (5.98 g ae/L) to the herbicide solution was to determine if glyphosate impacted 2,4-D metabolism. After absorbing the herbicide solution, leaves were transferred to tubes containing water until they were harvested at 1, 3, 6, 12, or 24 hours after the leaves were placed in the herbicide solution. Harvested leaves were then frozen with liquid nitrogen, homogenized with a glass rod, treated with 14 mL of a 90% acetone, centrifuged, and the supernatant was used to prepare samples for analysis by HPLC to determine the amount of ^{14}C-2,4-D present. The Enlist soybean variety metabolized more 2,4-D at all time points compared to the NT variety and at 24 hours after herbicide application (HAA) the amount of 2,4-D metabolized in Enlist soybeans was 95.6% compared to 58.4% in NT soybeans. When glyphosate was added with 2,4-D, metabolism was not affected in either Enlist or NT soybean. Enlist corn had greater 2,4-D metabolism than NT corn at all time points except 1 HAA (33% compared to 28%). By 24 HAA, Enlist corn metabolized 93.4% of the 2,4-D compared to 78.0% in the NT variety. Glyphosate did not slow 2,4-D metabolism in soybeans, indicating 2,4-D uptake and/or translocation may impact crop injury more than metabolism. Further research investigating the cell response during periods of rapid 2,4-D uptake immediately after application will provide a greater understanding of the cause of leaf necrosis.

2,4-D TRANSLOCATION AND METABOLISM IN SENSITIVE AND TOLERANT RED CLOVER (*TRIFOLIUM PRATENSE*) LINES. Tara L. Burke*, Michael Barrett; University of Kentucky, Lexington, KY (138)

Grass pastures benefit greatly from the incorporation of a legume, such as red clover (Trifolium pratense). However, susceptibility of red clover to herbicides commonly used in these systems limits its use; the University of Kentucky pasture weed management guide states that “In grass pastures interseeded with clover or other forage legumes, selective herbicide options are not available”. A 2,4-D tolerant red clover would expand the weed management options for interseeded pastures, as 2,4-D has been the standard for weed management in pastures for decades. A Florida red clover line with improved 2,4-D tolerance was crossed to the 2,4-D susceptible Kenland cultivar and the resulting population was selected for 2,4-D tolerance (2006-2013). To assess 2,4-D tolerance, plants were grown in the greenhouse from seed collected after the 2010, 2011 and 2012 selections and treated with 0.0, 0.56, 1.12, 1.68, or 2.24 kg ha-1 of 2,4-D. Plant visual injury ratings at two weeks post-treatment were compared to the similarly treated parent lines (Florida line and Kenland). The 2010 and 2011 lines had 2,4-D tolerance similar to the Florida parent. Thus, while the cross to the 2,4-

D tolerant Florida line increased 2,4-D tolerance compared to Kenland, little additional gain had been made in 2,4-D tolerance beyond that of the Florida line, despite numerous rounds of selection for 2,4-D tolerance. However, further selections have increased 2,4-D tolerance slightly. To establish the basis for the increased tolerance, leaves of plants of Kenland and those grown from seed after the 2013 selection were treated with 14^{C}- 2,4-D. Both lines had similar uptake of 2,4-D. However, there were significant differences between the two lines in terms of 2,4-D translocation and metabolism. More of the 2,4-D was metabolized in the treated leaf of the 2013 selection and less of the radioactivity was translocated to untreated plant in this line as well. This points to a possible role for increased metabolism and reduced translocation as the basis for increased 2,4-D tolerance in the selected red clover.

INFLUENCE OF NOZZLE TYPE AND WIND SPEED ON TOMATO INJURY FROM DICAMBA APPLICATIONS. Ryan S. Henry*[1], Cody F. Creech[1], Sanela Milenkovic[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (139)

Field scale experiments of pesticide drift are necessary for product or technology assessment; however, these types of experiments can be labor intensive and expensive. It would therefore be beneficial to evaluate pesticide drift in a more controlled setting. A low speed wind tunnel at the Pesticide Application and Technology Laboratory in North Platte, NE was used to evaluate the drift potential of six different nozzles and three herbicide solutions in a 4.5 m/s airflow. Pesticide drift was measured at six downwind locations, zero to 12.2 meters, in the wind tunnel. At each location, a collection station consisting of a mylar card, string, and a tomato (*Solanum lycopersicum*) plant were included to measure deposition, airborne flux, and biological injury, respectively. Injury was observed at all locations, regardless of nozzle type or formulation. Fluorometric analysis of mylar cards and strings indicated deposition and flux were lowest for the venturi-type nozzles tested, but there was variability across the specific nozzles. Particle flux was lowest for the nozzles classified as extremely coarse or ultra-coarse at 12.2 meters downwind. An ultra-coarse spray quality reduced deposition by 90 percent, relative to the flat-fan nozzle. The results of this study demonstrated the potential for using low speed wind tunnels for drift simulations, although the development of the methodology is ongoing.

INFLUENCE OF SPRAY NOZZLE DESIGN ON SPRAY SOLUTION DEPOSITION ON PALMER AMARANTH (*AMARANTHUS PALMERI*) AND COMMON WATERHEMP (*AMARANTHUS RUDIS*). Travis R. Legleiter*[1], William G. Johnson[2], Bryan Young[3]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN, [3]Purdue University, W. Lafayette, IN (140)

Concern over off-target spray particle drift of postemergence, systemic herbicides associated with the use of new herbicide-resistant soybean traits has prompted research on the use of broadcast spray nozzles with pre-orifice, turbulence chamber, and air induction designs that produce very coarse to ultra coarse droplets. Experiments were conducted at two Indiana locations in 2014 to evaluate the herbicide deposition and coverage on glyphosate resistant Palmer amaranth and common waterhemp as influenced by broadcast spray nozzle designs. Glyphosate plus 2,4-D was applied with TeeJet brand Extended Range, Turbo TeeJet, Air Induction Extended Range, and Turbo TeeJet Induction nozzles to 10 to 20 cm tall Palmer amaranth and common waterhemp in 38-cm row soybean. Applications were made with an ATV sprayer traveling 19 km hr^{-1} equipped with 11004 nozzles at a pressure of 276 kPa. Fluorescent and foam marker dye were added to the spray solution prior to application for evaluation of herbicide deposition on leaf surfaces and Kromekote cards, respectively. Deposition density on the Kromokote cards was less with the Turbo TeeJet Induction and Air Induction Extended Range nozzles as compared to the Turbo TeeJet and Extended Range nozzles. Despite the differences in deposition density, the nozzle type did not influence the total deposition on Palmer amaranth and common waterhemp plants. Thus, the use of drift reduction nozzles on these weed species may not compromise herbicide efficacy since total spray deposition on leaf surfaces were not reduced

EFFECT OF FOLIAR FERTILIZERS AND WATER PH ON WEED CONTROL WITH MON 76783, ENLIST DUO, AND GLUFOSINATE. Pratap Devkota*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (141)

Water is an important carrier solvent for herbicide application, and efficacy of herbicides can be reduced by inappropriate spray water quality. Likewise, cations from co-applied foliar fertilizers have potential to antagonize herbicide activity. Field studies were conducted at TPAC/Meigs Research Farm, Purdue University; and Winamac, IN to evaluate the effect of foliar fertilizer, and carrier water pH on mesotrione, premix formulation of 2,4-D plus glyphosate, glufosinate, and premix formulation of dicamba plus glyphosate on horseweed and Palmer amaranth. Water treatments consisted of combinations of zinc or manganese fertilizers (at 2.5 and 3.75 L ha^{-1}, respectively) and water pH of 4, 6.5, or 9. Zinc fertilizer reduced mesotrione efficacy on Palmer amaranth compared to manganese fertilizer. At carrier water pH of 6.5, mesotrione efficacy was higher compared to water pH of 4 and 9 for horseweed control. Likewise, glyphosate plus 2,4-D applied with carrier water pH of 4 provided greater control of horseweed compared to carrier water pH of 9. Palmer amaranth control was higher with glufosinate applied with carrier water pH of 4 compared to water pH 6.5 and 9 at 2 and 4 WAT. There was an interaction of foliar fertilizer and carrier water pH on Palmer amaranth control with glyphosate plus dicamba. Zn fertilizer applied at water pH of 9 provided the lowest control (≤84%) of Palmer amaranth compared to other treatment combinations (≥92%) at 4 WAT. Likewise, glyphosate plus dicamba applied with carrier water pH of 4 provided higher control of horseweed and Palmer amaranth compared to water pH 9. However, there was no reduction in biomass with glyphosate plus dicamba applied at carrier water pH of 4 compared to water pH of 9. In conclusion, extremes in carrier water pH have potential for reducing herbicide efficacy; however, the effect of carrier water pH is variable depending on herbicide and weed species.

GLYPHOSATE CANOPY PENETRATION IN CORN AND SOYBEAN AS INFLUENCED BY NOZZLE TYPE, CARRIER VOLUME, AND DRIFT CONTROL ADJUVANT. Cody F. Creech*[1], Ryan S. Henry[1], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (142)

Herbicide canopy penetration of a crop is necessary for a herbicide application to reach a target weed species when applications are made after crops have become firmly established. When crops are actively growing, off-target herbicide movement can cause severe injury. The objective of drift reduction technology is usually to increase droplet size to reduce the number of smaller droplets with the highest propensity to be moved off-target by the wind. The adoption and use of drift reducing technologies to mitigate off-target movement on herbicide canopy penetration has not been fully investigated. This study evaluated the performance of four nozzles (XR, AIXR, AITTJ, and TTI), two carrier volumes (94 and 187 L ha^{-1}, with and without a drift reducing adjuvant. Applications were made to corn and soybean fields near North Platte and Big Springs, NE. Treatments applied in North Platte were applied 60 cm above the crop canopy with an 18 m spray boom. Big Springs treatments were applied at the same height with an 30 m boom. Each boom was divided into five sections, one for each nozzle, utilizing a split-plot design, and a plugged section for an untreated control. Glyphosate was applied at 1.26 kg ae ha^1 with ammonium sulfate at 5% v/v. A rhodamine dye was added (0.025% v/v) to the spray tank of each mix as a tracer. For each nozzle section, 10 x 10 cm mylar cards were placed in the field above the canopy, in the middle of the canopy, and on the ground below the canopy and arranged across the crop row. After the application was made, cards were collected, rinsed with distilled water, and analyzed for dye concentration individually. Samples were analyzed using a fluorimeter. The study was replicated four times for each treatment at each location in each crop. Data were transformed to represent the percent reduction of the spray collected compared to what was recovered at the top of the canopy. Data were analyzed as a split-plot design where the spray mixture was the whole plot and the nozzle type was the sub-plot. The addition of a drift reducing adjuvant did not impact canopy penetration. Doubling the carrier volume increased the amount of penetration proportionally and as such the percent reduction was not different. The TTI nozzle (28%) had the greatest penetration in the soybean canopies and the XR (50%) nozzle was greatest in the corn canopies. Deposition across the row, beginning in between the row crop and ending in the row of the crop was 44, 18, and 8% for soybean and 59, 50, 36% for corn. For both crops, more than half of the herbicide application was captured in the crop canopy. Proper nozzle selection for canopy type can increase herbicide penetration and increasing the carrier volume will increase the volume of spray penetration proportionally.

WHICH ADJUVANTS INCREASE GLUFOSINATE EFFICACY? Theresa A. Reinhardt*, Rich Zollinger, Kirk Howatt, Devin A. Wirth; North Dakota State University, Fargo, ND (143)

Glufosinate is an important herbicide active ingredient as it is the only herbicide acting on glutamine synthesis. Having characteristics of a contact herbicide, adding an oil adjuvant would likely enhance glufosinate efficacy, however, that is not necessarily the case. AMS has increased glufosinate activity in many studies. Glufosinate plus AMS could be optimized through adjuvant combination. Field studies were conducted near Hillsborro, ND in 2012 and 2013 to compare glufosinate activity at 448 g ai ha^{-1} with AMS at 3.36 kg ha^{-1}, NIS 0.25% v/v, PO at 946 ml ha^{-1}, MSO at 591 ml ha^{-1}, and HSOC 473 ml ha^{-1} alone and in combination with AMS. Treatments were applied to the center 2 meters of 3 by 12 meter plots using a CO_2 backpack sprayer fitted with 11002 Turbo TeeJet nozzles. Plots were planted with *Linum usitatissimum* L., *Chenopodium quinoa* Willd., *Fagopyrum esculentum* Moench, and *Amaranthus* species in 3 meter strips perpendicular to the plots for evaluation of efficacy. Although not statistically different, AMS and AMS + HSOC increased efficacy 9% higher than any other treatment. The addition of MSO did not increase efficacy compared to glufosinate alone. Results indicate AMS may remain the most critical tank-mix partner, but can enhance other adjuvant combinations.

MARKETABILITY AND SEED PRODUCTION EFFECTS FROM GLYPHOSATE DRIFT INJURY TO RED NORLAND POTATO. Amanda Crook*[1], Harlene M. Hatterman-Valenti[2], Collin Auwarter[1]; [1]NDSU, Fargo, ND, [2]North Dakota State University, Fargo, ND (144)

Field research was conducted at the NPPGA Research site near Grand Forks, ND in 2014 to evaluate the effects when sub-lethal rates of glyphosate where applied to 'Red Norland' potatoes. Glyphosate was applied at one-quarter, one-eighth, one-sixteenth and one-thirty-second the standard use rate (0.050, 0.105, 0.201, and 0.402L/ha) during three crucial growth stages: tuber initiation (TI), early tuber bulking (EB) and late tuber bulking (LB). Data was collected on yield, total tuber numbers, number of damaged-cracked tubers and tubers less than 56.7g (undesirable size for seed). Visible foliar damage symptoms (chlorosis at the growing points) were most noticeable at the TI stage due to the determinant growth nature of this cultivar. Although no significant yield differences occurred, other symptoms developed creating unmarketable tubers for the fresh market or creating severely undersized tubers for seed production. Glyphosate applied to plants at the EB and LB growth stages did not affect total tuber number, total cracked tuber number or less than 56.7g seed pieces. In contrast, glyphosate applied at 0.105, 0.201 and 0.402 L/ha to plants at the TI stage resulted in greater total tuber numbers. Additionally, glyphosate applied at all sub-lethal rates to plants at the TI stage resulted in more damaged-cracked tubers. More daughter tubers were less than 56.7g when plants at the TI stage were treated with 0.201 and 0.402 L/ha glyphosate. Further research is focusing on sprout inhibition on daughter tubers used for seed pieces as well as quantifying glyphosate residue within the seed pieces.

ALTERNATIVE WEED CONTROL OPTIONS DURING VINEYARD ESTABLISHMENT IN NORTH DAKOTA. John E. Stenger*[1], Collin P. Auwarter[2], Harlene M. Hatterman-Valenti[1]; [1]North Dakota State University, Fargo, ND, [2]NDSU, Fargo, ND (145)

To address questions regarding viable options for weed management in North Dakota vineyards, a comparison of weed control methods on weed control and effect on vine growth was conducted. An experimental vineyard (Absaraka, ND) was arranged in a randomized complete block design with full factorial including four white wine cultivars (Alpenglow, Brianna, Frontenac Gris, and LaCrescent) and six weed control methods (Landscape Fabric, Herbicide (glufosinate-ammonium, 0.65 kg ai ha^{-1}, with flumioxazin, 0.21 kg ai ha^{-1}), Black Plastic, Straw Mulch, Tillage, and Turfgrass) and four replications. Weed control was visually evaluated June through September. The most prevalent weed species of the area were common lambsquarters (*Chenopodium album*) and barnyardgrass (*Echinochloa crusgalli*). Overall, straw mulch, black plastic, landscape fabric, and herbicide were effective in controlling the weed species present. Turfgrass lacked control in 2013 during its establishment, however it was effective in 2014. Tillage tended to have weaker control of weeds early in the season. Weed control measures also had effects on vine growth and hardiness. Dormant pruning weights differed across seasons, cultivars, and weed control measures. Bud retention and number of live buds were affected by weed control method leading to a significant influence on the ability to establish cordons in the spring of 2014. In all cases, turfgrass and straw mulch generally depressed the growth of all cultivars in both years. Black Plastic, Landscape Fabric, and Herbicide aided in vine growth and establishment. Our findings suggest that black plastic or landscape fabric may be viable weed control alternatives in North Dakota vineyards.

UTILIZING R SOFTWARE FOR RESPONSE SURFACE DATA ANALYSIS IN APPLICATION TECHNOLOGY AND WEED SCIENCE. Strahinja Stepanovic*[1], Ryan S. Henry[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, Grant, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (146)

Recent developments in experimental procedures for evaluating drift potential initiated the need to develop experimental designs and statistical analysis that will optimize the use of information generated from such studies. The study was conducted in the wind tunnel facility at Pesticide Application Technology Laboratory (PAT Lab) in North Platte, NE to demonstrate the use of R software in modeling response surfaces that arise from a range of operating pressures and carrier volumes and determine how they impact droplet size and drift potential. Dicamba and glyphosate were applied in enclosed wind tunnel using XR8002 and AIXR11004 nozzle tips, wind speed of 8 km h^{-1}, eight different spray volumes ranging from 19 to 187 l ha^{-1} in 19 l ha^{-1} increments and 30 different operating pressures ranging from 138 to 552 kPa in 14 kPa increments. Droplet size spectra measurements including Dv10, Dv50 and Dv90 were measured for each treatment combination. Data were fitted to first-, second-, and third-order polynomial models and generalized additive model (nonparametric smoother), and corrected Akaike's information criterion (AICc) was used to compare models and identify which model provides the best fit to the data. R showed to be a very useful statistical software in analyzing response surface experiment and determining combination of operating pressure and carrier volume that minimizes drift potential. Depending on the research objective similar experimental design and statistical analysis can be used in various agronomic experiments to find optimal combinations of two quantitative variables (e.g. find combination of irrigation and nitrogen application that maximizes crop yield).

COVER CROP TRENDS IN THE UNITED STATES. Erin C. Hill*; Michigan State University, East Lansing, MI (147)

Cover crops have been used to improve agricultural ecosystems since the early days of agriculture; however use declined over the past century with the advances in synthetic fertilizers, herbicides, and other agricultural technologies. Today, cover crops are being reconsidered as one viable approach to address growing concerns related to surface water pollution, soil health, and herbicide-resistant weeds. Approximately 2% of grain and oilseed production land in the U.S. includes cover crops in the rotation, according to the most recent census of agriculture (i.e. 2012). This percentage is expected to rise with the increasing availability of cost-share programs and farmer interest across the nation. Revisiting cover crops has revealed knowledge gaps, particularly with regard to the successful establishment and management when herbicides are used in the rotation. Most cover crop species are not listed on herbicide labels in the rotation restrictions or species controlled. This symposium is ideally timed to share information among researchers investigating cover crop and herbicide interactions with a goal of increasing farmer success with cover crops.

COVER CROP AND HERBICIDE INTERACTIONS: A MICHIGAN PERSPECTIVE. Erin C. Hill*, Christy L. Sprague, Karen A. Renner; Michigan State University, East Lansing, MI (148)

Michigan is ranked fifth in the nation in terms of cover crop acreage; with over 400,000 cover crop acres representing nearly 6% of the total cropland in the state. As cover crop use has increased so have grower questions to Michigan State University Extension. Top concerns in Michigan include: carryover issues with herbicides used prior to cover crop establishment, cover crop termination with herbicides, and the potential for cover crops to become weeds. Ongoing field and greenhouse experiments examine the influence of residual corn and soybean herbicides on the establishment and growth of cereal rye, oilseed radish, and medium red clover, and the impact of postemergence wheat herbicides on established medium red clover. Early results indicated that cereal rye, currently the most widely used cover crop in Michigan, is the least susceptible of these three cover crops to residual corn and soybean herbicides. Medium red clover establishment was negatively impacted by fall applications of mesosulfuron (i.e.

Osprey) to winter wheat. Spring herbicide applications (i.e. May) to wheat resulted in 80-100% injury of frost-seeded (i.e. April) medium red clover. Research and extension efforts regarding cover crop and herbicide interactions will continue in Michigan over the next several years.

COVER CROP ADOPTION AND UTILIZATION IN THE MID-ATLANTIC; A COMBINATION OF STAUNCH ENTHUSIASM AND ANXIOUS UNCERTAINTY. William Curran*[1], Dwight D. Lingenfelter[2]; [1]Penn State, University Park, PA, [2]Penn State University, University Park, PA (149)

Cover crop enthusiasm in the mid-Atlantic region has grown rapidly. Both researchers and farmers are testing new ways to establish and manage cover crops in no-till systems. The most frequent questions asked to regional weed science extension specialists include concerns about appropriate herbicides that will allow successful cover crop establishment on the front end and how to kill or control cover crops on the back end before no-till establishment of cash crop. We have had several studies focused in both of these areas. Our herbicide carryover research to date suggests that most of the herbicides used in corn and soybean are relatively safe to common fall seeded cover crops. The exception to this is some concern to small seeded legumes and *Brassica* species from selected herbicide products. The type of research necessary to determine crop safety can be time consuming mostly because the research needs to be conducted at multiple locations and perhaps over multiple years to have the confidence necessary to make sound recommendations. As an alternative, we have focused our efforts on using herbicide half-life information published in the scientific literature along with cover crop sensitivity or susceptibility in explaining the potential impact of herbicides on cover crop establishment. A major limiting factor with this approach is reliance on half-life information which can vary quite widely depending on soil and environmental factors. However, we believe this approach is conservative and will likely over predict potential problems, but this is preferable to the alternative. Herbicide applicators have also expressed concern about adequate control of certain cover crops and especially cereal rye and annual ryegrass in the spring in their burndown program. Our cover crop control experiments have routinely showed that herbicides can effectively control grass and legume cover crops with few problems assuming the correct product and rate are selected. We have concluded that greater attention to detail at application time that includes using the appropriate carrier volume, herbicide, herbicide rate, and avoiding certain tank-mixtures can eliminate or reduce the potential for poor herbicide performance.

COVER CROP RESEARCH AND EXTENSION NEEDS IN NORTHERN MIDWEST FARMING OPERATIONS. Elizabeth J. Bosak*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (150)

Cover crop use and adoption in Northern Midwest farming systems differs from central and Southern Midwestern states because of greater demand to produce forage to feed dairy operations and the shorter growing season restricts available time for cover crop establishment. In 2012, the Northern Midwest states of Michigan, Minnesota, and Wisconsin had over 2 million dairy cattle compared to the central states of Illinois, Indiana, and Ohio with 0.5 million dairy cattle. Production of three key components of the dairy herd ration: corn silage, grass hay, and alfalfa hay in the North covered two to three times more acreage than the central states. The Northern Midwest climate poses several challenges for following a cash crop with a cover crop because of a short freeze-free period to establish crops and a limited number of growing degree days to generate biomass. In Michigan, Minnesota, and Wisconsin, the freeze-free period ranges from 60 to 150 days with 1950 growing degree days between March 1 and September 1 compared to central states that range from 120 to 180 days with 3000 growing degree days. Given the restricted growing season and the need to produce forage along with high land rent cost, farmers may consider double-cropping a desirable alternative to purchasing feed. Research is needed to establish the economic and environmental benefits, and consequences, of double-cropping rather than following a cash crop:cover crop rotation. Extension efforts need to include information and discussions of herbicide rotational restrictions when a farmer implements a cash crop:forage crop rotation. To assist farmers with double-cropping forages, we have developed a series of fact sheets based on herbicide rotational restrictions for fifteen different cover crops that could be used for forage. A comprehensive guide, “Herbicide Rotation Restrictions in Forage and Cover Cropping Systems”, includes all small grain, soybean, and corn herbicide rotation restrictions. Due to the sheer number of herbicides listed, we then developed two specific forage fact sheets, “Forage Herbicide Quick Sheet: Cereal Rye Forage after Corn Silage” and “Forage Herbicide Quick Sheet: Spring-Seeded Forages after Corn.” Both of these fact sheets limit the herbicides to those that are feasible given their rotational restrictions and include the site-of-action group numbers to aid in herbicide resistance management planning.

POTENTIAL FOR HERBICIDE RESIDUES TO IMPACT COVER CROP ESTABLISHMENT AND FUNCTION. Darren Robinson*; University of Guelph, Ridgetown, ON (151)

Cover crops offer many potential benefits to vegetable products systems, including managing for erosion, sequestering soil nitrogen, soil improvement and pest management. One aspect that can significantly impact cover crop establishment, but has received little attention is the effect of residual herbicides on subsequent cover crop establishment and function. Three trials were established in 2011 and again in 2012 to examine effect of residues of flumetsulam, saflufenacil/dimethenamid-p, mesotrione+s-metolachlor/atrazine isoxaflutole+atrazine and imazethapyr on establishment and function of 12 cover crops, including spring- and fall-seeded grass and broadleaf cover crops, and four legume cover crops. The first objective of this work was to determine how soil water holding capacity and nutrient uptake of non-leguminous species (ie. annual (cereal) rye, wheat, oat, (annual) ryegrass, sorghum-sudangrass, buckwheat, oilseed radish) are affected by residual herbicides applied in the previous year. Soil water holding capacity and nutrient uptake of non-leguminous species (ie. annual ryegrass, wheat, oat, fall rye, sorghum sudangrass, buckwheat, oilseed radish) were affected differently by residual herbicides applied the previous year. Specifically, flumetsulam and imazethapyr reduced ability of oilseed radish, fall oats, and buckwheat, and sorghum sudangrass to improve soil water holding capacity and scavenge nitrogen. Mesotrione+s-metolachlor/atrazine reduced ability of annual ryegrass and buckwheat to improve soil water holding capacity and scavenge nitrogen. Despite the visible injury saflufenacil/dimethenamid-p and isoxaflutole+atrazine caused to annual ryegrass, they did not reduce the ability of this cover crop to improve soil water holding capacity and scavenge nitrogen – this is likely because the cover crop stand, and root and shoot biomass were not negatively impacted by either herbicide treatment. The second objective of this study was to determine the relationship between soil water holding capacity and organic matter production of crimson clover, hairy vetch, red clover and sweet clover, and application of residual herbicides in the previous year. Crimson clover, red clover and sweet clover were not negatively affected by herbicide residues of flumetsulam, saflufenacil/dimethenamid-p, isoxaflutole+atrazine and imazethapyr. As a result, their ability to improve soil water holding capacity and organic matter were not affected by any herbicide residues. This is important, as it shows the compatibility of the different clover species with many commonly used corn and soybean herbicides. Research has shown that mesotrione+s-metolachlor/atrazine will carry over onto red clover and reduce its ability to improve soil water holding capacity and soil organic matter.

SOIL-APPLIED HERBICIDES OVER SPRING SEEDED COVER CROPS. Thomas J. Peters*, Aaron L. Carlson; North Dakota State University, Fargo, ND (152)

Sugarbeet growers in Eastern North Dakota and Minnesota used spring-seeded cereal cover crops on 39% of their acreage in 2013 to protect sugarbeet from wind and soil erosion during stand establishment (number derived from phone interviews with Production Agronomists). Waterhemp (Amaranthus spp.), a summer annual broadleaf weed in the amaranthaceae family, has become an important weed control challenge for sugarbeet growers in Eastern North Dakota and Minnesota. Some growers are using soil-applied herbicides to control waterhemp, partly due to increased occurrences of glyphosate-resistant waterhemp in sugarbeet. However, cover crop species tolerance to soil-applied herbicides is not well-researched. Thus, sugarbeet growers today must decide between either use of cover crops or soil-applied herbicides, but not both. Field experiments were conducted near Lake Lillian, MN, Herman, MN, Foxhome, MN, and Crookston, MN to investigate tolerance of barley, oat, and, wheat cover crops to soil-applied herbicides and rate for control of waterhemp in sugarbeet in 2014. Cover crops were seeded perpendicular to sugarbeet rows using a spreader calibrated to deliver 1 bu/A. Cover crops were incorporated with a field cultivator prior to planting sugarbeet. Herbicides were applied to the center four rows of six row plots with a bicycle wheel plot sprayer delivering 159 L/ha water carrier at 276kPa through 8002XR nozzles. Cereal crop ground cover, sugarbeet injury, and waterhemp control assessment was done visually and by taking count data approximately 21 to 28 days after planting. Count data were the number of plants per square meter. Visual evaluation was an estimate of percent control in the treated plot area compared to the adjacent untreated strips using a scale of 0 (no control) to 100% (complete control). Cover crops responded differently to soil-applied herbicides. In general, oat was the most tolerant and wheat the least tolerant cereal species. Oat, barley, and wheat percent ground cover, measured by comparing stand count to the untreated control, was 81, 86 and 77 %, respectively, following s-metolachlor application preemergence at 0.53 kg/ha. Oat tolerated ethofumesate at 1.12 and 1.68 kg/ha but wheat and barley stand loss was too great. With the exception of oat, loss of cereal crop stand was greater from s-metolachlor plus ethofumesate than s-metolachlor or ethofumesate alone. Sugarbeet injury generally was negligible across locations. At Foxhome, sugarbeet injury from ethofumesate was greater than other herbicide treatments. Ethofumesate alone and ethofumesate plus metolachlor tended to cause more sugarbeet injury at Crookston. Early and late season waterhemp control generally was better with s-metolachlor in combination with ethofumesate than with either s-metolachlor or ethofumesate alone.

COMPARISON OF HERBICIDE PROGRAMS WITH AND WITHOUT RESIDUAL HERBICIDES FOR WEED CONTROL IN GLUFOSINATE-RESISTANT SOYBEAN. Jatinder S. Aulakh*[1], John L. Lindquist[2], Amit J. Jhala[3]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (153)

Due to increasing incidence of glyphosate-resistant weeds in glyphosate-resistant soybean, alternate herbicide programs are required. Glufosinate is an alternate POST herbicide for weed control in glufosinate-resistant soybean. Field experiment was conducted near Clay Center, NE in 2012 and 2013 to compare herbicide programs with glufosinate applied sequentially or with PRE herbicides followed by (fb) glufosinate tank-mixed with residual herbicides in glufosinate-resistant soybean. Results revealed that PRE herbicides provided 84 to 99% control of common lambsquarters, common waterhemp, Eastern black nightshade, velvetleaf, green foxtail, and large crabgrass at 15 d after application. At harvest, single or sequential applications of glufosinate controlled broadleaf and grass weeds ≤ 87%. A PRE application of flumioxazin or sulfentrazone plus cloransulam-methyl/imazethapyr fb LPOST glufosinate provided ≥ 78% weed control. Tank-mixing glufosinate with acetochlor, pyroxasulfone, or *S*-metolachlor following flumioxazin plus chlorimuron-ethyl, and sulfentrazone plus metribuzin PRE resulted in 87 to 99% weed control. Soybean injury at 4 days after LPOST application varied from 0 to 30% and was inconsistent over the two study yr. Soybean yields were higher when sulfentrazone plus metribuzin PRE was fb glufosinate tank-mixed with residual herbicides applied POST compared with all other herbicide programs in 2013. It is concluded that residual herbicides applied PRE and in tank-mix with glufosinate applied POST are important to achieve high level of weed control, reduce weed density and biomass, and increase soybean yields.

INFLUENCE OF TILLAGE METHODS ON MANAGEMENT OF *AMARNATHUS* SPECIES IN SOYBEAN. Jaime Farmer*[1], Vince M. Davis[2], William G. Johnson[3], Mark M. Loux[4], Jason K. Norsworthy[5], Lawrence E. Steckel[6], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Wisconsin-Madison, Madison, WI, [3]Purdue, West Lafayette, IN, [4]Ohio State University, Columbus, OH, [5]University of Arkansas, Fayetteville, AR, [6]University of Tennessee, Jackson, TN (154)

The increasingly difficult challenge of managing herbicide-resistant weeds has led to a renewed interest in cultural control methods such as tillage for weed control. An identical field trial was conducted in 2014 in Arkansas, Illinois, Indiana, Ohio, Tennessee, Wisconsin, and at two sites in Missouri to determine the effects of four tillage treatments on season long emergence of *Amaranthus* species in glufosinate-resistant soybean. The tillage treatments evaluated included deep tillage which consisted of a fall moldboard plow followed by (fb) one pass with a field cultivator in the spring, conventional tillage which consisted of a fall chisel plow fb one pass with a field cultivator in the spring, minimum tillage which was one pass of a vertical tillage tool in the spring, and a no-tillage treatment that received a burndown herbicide treatment at approximately the same time as the spring tillage passes. Each tillage treatment also received two herbicide treatments; a preemergence (PRE) application of flumioxazin fb a postemergence (POST) application of glufosinate plus Smetolachlor, and POST-only applications of glufosinate. The experimental design was a split-plot arrangement of treatments with four replications. Whole plots consisted of tillage types while subplots were herbicide treatments. Weed counts were taken in two 1-m^2 quadrants within the middle two rows of each plot every 2 weeks following planting up to the R6 stage or soybean senescence. Following each count the entire trial was sprayed with glufosinate and emerged seedlings were removed to ensure no weed escapes. Six, 2.5 cm soil cores were also taken to a depth of 25-cm from each plot after soil preparation and prior to planting and herbicide application to determine the vertical distribution of weed seed in the soil profile. Each soil core was divided into six sections corresponding to depths of 0-1, 1-5, 5-10, 10-15, 15-20, and 20-25 cm in the soil profile. Each soil segment was spread as a topsoil layer over 3-cm deep containers filled with commercial potting medium. Seedling emergence was monitored over a 3 month time period. Emerged weed seedlings were counted and identified to species every 2 weeks, then removed from the pots after counting. Across all locations and tillage types, cumulative weed emergence was at least 50% less with the residual herbicide compared to the POST-only herbicide program. Across 4 of the locations that contained adequate weed densities, cumulative weed emergence was 20 to 79% lower in response to deep tillage compared to the no-tillage treatment. Conventional tillage generally resulted in slight reductions in cumulative weed emergence compared to no-tillage, while minimum tillage resulted in cumulative weed densities similar to or higher than the no-tillage treatment. Based on soil cores collected from each location, an average of 71% of the total weed seedbank was concentrated in the upper 5 cm of soil in the no-tillage treatment, while conventional, minimum, and deep tillage contained 58%, 68%, and 36% of the weed seedbank, respectively.

PALMER AMARANTH WEED CONTROL WITH ENLIST WEED CONTROL SYSTEMS. David M. Simpson*[1], Kristin Rosenbaum[2], Jeff M. Ellis[3], John S. Richburg[4], Fikru Haile[5], Leah L. Granke[6], Gary D. Thompson[7], Bobby H. Haygood[8], Larry W. Walton[9]; [1]Dow AgroSciences, Indianapolis, IN, [2]Field Scientist, Crete, NE, [3]Dow AgroSciences, Smithville, MO, [4]Dow AgroSciences, Headland, AL, [5]Dow AgroSciences, Carmel, IN, [6]Dow AgroSciences, Columbus, OH, [7]Dow AgroSciences, Omaha, AR, [8]Dow AgroSciences, Collierville, TN, [9]Dow AgroSciences, Tupelo, TN (155)

Isolated populations of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri S. Wats.*) have been identified in corn and soybean fields in Michigan, Ohio, Illinois, Indiana and Iowa. Due to its long germination period and rapid growth, glyphosate- resistant Palmer amaranth weed control programs will require utilization of residual preemergence (PRE) and one or two postemergence (POST) herbicide applications. Enlist E3™ soybean provides tolerance to glyphosate, 2,4-D and glufosinate. Enlist Duo™ herbicide with Colex-D™ technology is a proprietary blend of 2,4-D choline (195 g ae/L) + glyphosate DMA (205 g ae/L). Research was initiated to characterize Palmer amaranth weed control with Enlist Duo, 2,4-D choline and glufosinate in the POST component of the weed control program. Fourteen studies were conducted across the Midwest and Southern United States from 2013 through 2014 to characterize glyphosate resistant Palmer amaranth control in weed control programs consisting of a residual herbicide applied at planting (PRE) followed by a single POST application or two sequential POST applications. The PRE herbicide treatments in 2013 consisted of flumioxazin + cloransulam (71.5 + 23.5 g ai/ha), sulfentrazone + cloransulam (136.6 + 17.5 g ai/ha) or flumioxazin + chlorimuron (62.7 + 21.6 g ai/ha) and in 2014 consisted only of flumioxazin + cloransulam (71.5 + 23.5 g ai/ha). The POST treatments were single applications made to less than 4 inch tall Palmer amaranth or sequential POST applications made to less than 4 inch Palmer amaranth followed by a second application 14 to 21 days later. Single POST herbicide treatments were Enlist Duo at 2185 g ae/ha, glufosinate at 542 g ae/ha, 2,4-D choline + glufosinate at 1065 + 542 g ae/ha, Enlist Duo + metolachlor at 2185 + 1070 g ae/ha, Enlist Duo + fomesafen + metolachlor at 2185 + 266 + 1214 g ae/ha, 2,4-D choline + glufosinate + metolachlor at 1065 + 542 + 1070 g ae/ha and 2,4-D + glufosinate + fomesafen + metolachor at 1065 + 542 + 266 + 1214 g ae/ha. Sequential POST herbicide treatments were Enlist Duo at 2185 g ae/ha followed by (fb) Enlist Duo at 2185 g ae/ha, glufosinate 542 g ae/ha fb glufosinate at 542 g ae/ha, Enlist Duo at 2185 g ae/ha fb glufosinate 542 g ae/ha, glufosinate at 542 g ae/ha fb Enlist Duo at 2185 g ae/ha and 2,4-D choline + glufosinate at 1065 + 545 g ae/ha fb 2,4-D choline + glufosinate at 1065 + 542 g ae/ha. N-PAK AMS at 2.5% v/v was added to all glyphosate and glufosinate containing treatments. Applications were made with CO2-pressurized backpack sprayers delivering a spray volume of 140 L/ha. PRE application of flumioxazin + cloransulam or flumioxazin + chlorimuron provided on

average 81% control of Palmer amaranth at 42 days after PRE application. The program of a PRE herbicide followed by POST applications of Enlist Duo, glufosinate or 2,4-D + glufosinate provided 96% control at 14 days after application. The addition of metolachlor with or without fomesafen to Enlist Duo did not increase control but did slightly increase control when applied with 2,4-D choline + glufosinate or glufosinate alone. At 14 days after second POST application, sequential applications of Enlist Duo or glufosinate resulted in at least 98% control compared to 94% with a single POST application of Enlist Duo™ herbicide. Sequential POST applications of Enlist Duo and glufosinate, in either order, resulted in 98% control of Palmer amaranth at 14 days after second POST application. No differences in control of glyphosate resistant Palmer amaranth was observed between the southern and northern locations. Integrating Enlist Duo into a program approach that includes preemergence applied herbicides provided excellent control of glyphosate-resistant Palmer amaranth.
™®Colex-D, Enlist, Enlist Duo and Enlist E3 are trademarks of The Dow Chemical Company ("Dow") or an affiliated company of Dow. Enlist E3 soybeans are jointly developed by M.S. Technologies and Dow AgroSciences. Regulatory approval is pending for Enlist cotton. Enlist Duo herbicide is not registered for sale or use in all states. Contact your state pesticide regulatory agency to determine if a product is registered for sale or use in your state. Always read and follow label directions.

WEED MANAGEMENT STEWARDSHIP OF ENGENIA™ HERBICIDE IN DICAMBA TOLERANT SOYBEAN. Shane Hennigh*[1], John Frihauf[2], Chad Brommer[2]; [1]BASF Corporation, Story City, IA, [2]BASF Corporation, Research Triangle Park, NC (156)

New weed control options are needed to manage herbicide resistant weeds that are limiting control tactics and in some areas cropping options. Dicamba tolerant soybean and cotton will enable the use of dicamba to manage these problematic weeds with an additional herbicide mechanism-of-action. In addition to being a new control tactic, 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 (EPA approval pending) is an advanced formulation based on the proprietary BAPMA (N, N-Bis-(aminopropyl) methylamine) dicamba that reduces potential secondary loss more than the improvement achieved with Clarity® herbicide. Over several years of testing, the most effective soybean weed control programs have utilized preemergence followed by well-timed postemergence applications (<4" weeds) like Optill® PRO followed Engenia plus glyphosate. Residual herbicides may be needed with postemergence applications in locations where multiple weed flushes occur. Engenia herbicide should be used as part of a comprehensive weed management strategy that includes cultural, biological, mechanical, and chemical control strategies to effectively manage herbicide resistant weeds and protect the utility of dicamba-tolerant cropping systems.

APPLICATION STEWARDSHIP OF ENGENIA™ HERBICIDE IN DICAMBA TOLERANT CROPS. Dustin Lewis*[1], Chad Brommer[2], Ching Feng[2], Walter E. Thomas[2]; [1]BASF Corporation, Urbana, IL, [2]BASF Corporation, Research Triangle Park, NC (157)

No abstract submitted

CONTROL OF VOLUNTEER ENLIST CORN IN SOYBEAN. Peter H. Sikkema*, Nader Soltani; University of Guelph, Ridgetown, ON (158)

Volunteer Enlist corn can become a problem when glyphosate-resistant soybean follows Enlist corn in a rotation. A total of four field trials were conducted at Ridgetown, Ontario over a two-year period (2013 and 2014) to evaluate the control of volunteer Enlist corn in glyphosate-resistant soybean. Treatments consisted of postemergence (POST) glyphosate at 900 g ae/ha alone (weedy control) and in tank-mix with clethodim (30 and 60 g ai/ha), fenoxaprop-p-ethyl (54 and 108 g ai/ha), fluazifop-p-butyl (75 and 150 g ai/ha), quizalofop-p-ethyl (36 and 72 g ai/ha) and sethoxydim (150 and 300 g ai/ha). Clethodim at 30 g ai/ha provided 75-92% control of volunteer Enlist corn at 1, 2, 4 and 8 weeks after treatment application (WAA) and reduced volunteer Enlist corn density and dry weight 95-97%. Clethodim at 60 g ai/ha provided 84-98% control of volunteer Enlist corn at 1, 2, 4 and 8 WAA and reduced volunteer Enlist corn density and dry weight 97-99%. Sethoxydim at 150 g ai/ha provided 66-86% control of volunteer Enlist corn at 1, 2, 4 and 8 WAA and reduced volunteer Enlist corn density and dry weight 91-97%. Sethoxydim at 300 g ai/ha provided 84-96% control of volunteer Enlist corn at 1, 2, 4 and 8 WAA and reduced volunteer Enlist corn density and dry weight 96-98%. Fenoxaprop-p-ethyl (54 and 108 g ai/ha), fluazifop-p-butyl (75 and 150 g ai/ha) and quizalofop-p-ethyl (36 and 72 g ai/ha) provided 0-9% control of volunteer Enlist corn at 1, 2, 4 and 8 WAA and reduced volunteer Enlist corn density and dry weight 21-44% and 18-41%, respectively. Soybean yields closely reflected the level of volunteer Enlist corn control. Based on these results, clethodim and sethoxydim at rates evaluated provide adequate control of volunteer Enlist corn in glyphosate-resistant soybean. However, fenoxaprop-p-ethyl, fluazifop-p-butyl and quizalofop-p-ethyl at rates evaluated do not provide adequate control of volunteer Enlist corn in glyphosate resistant-soybean.

THE EFFECT OF AUXINIC HERBICIDES ON GROWTH AND YIELD OF NON-AUXIN RESISTANT SOYBEANS. Kevin R. McGregor*[1], Micheal D. Owen[2]; [1]Iowa State University, Ankeny, IA, [2]Iowa State University, Ames, IA (159)

No abstract submitted

EVALUATION OF WEED CONTROL PROGRAMS UTILIZING HPPD-TOLERANT SOYBEANS. Aaron S. Franssen*[1], Dain E. Bruns[2], Thomas H. Beckett[3], Brett R. Miller[4], Donald J. Porter[3]; [1]Syngenta Crop Protection, Seward, NE, [2]Syngenta Crop Protection, Marysville, OH, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta Crop Protection, Minnetonka, MN (160)

Field trials were conducted from 2012 to 2014 to evaluate mesotrione-based weed control programs in HPPD-tolerant soybeans stacked with glyphosate tolerance. These multiple mode-of-action herbicide tolerant soybeans enable the use of mesotrione and isoxaflutole preemergence in addition to glyphosate postemergence. Several mesotrione-based herbicide programs provided control of key weed species, including glyphosate resistant populations. The most successful and consistent weed control was achieved with two-pass programs that included preemergence residual herbicides and multiple, overlapping modes of action. These programs were designed to align with HRAC principles of weed resistance management. The use of these chemically diverse and novel programs will offer effective, safe and sustainable weed management options for soybean growers.

BROADSPECTRUM WEED CONTROL IN SOYBEANS WITH FIERCE XLT. Trevor M. Dale*[1], Eric J. Ott[2], Dawn E. Refsell[3], Lowell Sandell[4], John A. Pawlak[5]; [1]Valent USA Corporation, Sioux Falls, SD, [2]Valent USA Corporation, Greenfield, IN, [3]Valent USA Corporation, Lathrop, MO, [4]Valent USA Corporation, Lincoln, NE, [5]Valent USA Corporation, Lansing, MI (161)

No abstract submitted

FIERCE XLT: A NEW HERBICIDE FOR CONTROL OF *AMARANTH* SPECIES IN SOYBEANS. John A. Pawlak[1], Dawn E. Refsell[2], Trevor M. Dale[3], Eric J. Ott[4], Lowell D. Sandell*[5]; [1]Valent USA Corporation, Lansing, MI, [2]Valent USA Corporation, Lathrop, MO, [3]Valent USA Corporation, Sioux Falls, SD, [4]Valent USA Corporation, Greenfield, IN, [5]Valent USA Corporation, Lincoln, NE (162)

No abstract submitted

OLD DOGS NEW TRICKS: VALUE OF METRIBUZIN IN MODERN WEED CONTROL FOR SOYBEANS. Neha Rana*[1], Keith Kretzmer[1], John B. Willis[1], Alejandro Perez-Jones[1], Paul Feng[1], Jesse Gilsinger[2]; [1]Monsanto Company, Chesterfield, MO, [2]Monsanto Company, Mount Olive, NC (163)

Metribuzin is a great value for an additional mode of action for weed control in soybeans. With the heavy reliance upon PPO chemistry and glyphosate in soybean weed control systems, weed scientists are strong proponents of utilizing a low rate of metribuzin (0.25 lb ai/A) to boost the level of control of glyphosate resistant *Amaranthus* species. To this effect, we studied numerous 2-way and 3-way tank-mix combinations of metribuzin with dicamba, acetochlor, and fomesafen herbicides. In all cases, the addition of metribuzin provided a significant increase in the level of weed control of glyphosate resistant palmer amaranth/waterhemp, as well as other broadleaf and narrowleaf weed species. Soybeans exhibit varietal sensitivity to metribuzin, but we have identified a marker for sensitivity that could potentially eliminate the need to screen for varietal sensitivity. Field experiments conducted in 2014 indicated marker selected lines provided adequate tolerance to metribuzin at 0.25 lb ai/A.

WATERHEMP CONTROL IN SUGARBEET. Aaron L. Carlson*, Thomas J. Peters; North Dakota State University, Fargo, ND (164)

Field experiments were conducted near Herman, Minnesota and Prosper, North Dakota in 2014 to evaluate sugarbeet injury and weed control from preplant incorporated (PPI), preemergence (PRE), postemergence (POST) and lay-by herbicide treatments. 'Crystal 981RR' sugarbeet was seeded 1-inch deep in 22-inch rows. Preemergence herbicides were applied to appropriate plots immediately after planting. Three POST applications were made at 8-day intervals. All treatments were applied in 17 gpa water at 40 psi through 8002XR nozzles to the center four rows of six-row by 30-foot long plots. Sugarbeet injury and waterhemp control were evaluated at each POST application and waterhemp control was evaluated 48 days after treatment (dat). In the POST herbicide trial, sugarbeet injury was negligible when glyphosate was applied alone or in combination with ethofumesate, desmedipham & phenmedipham, triflusulfuron, or clopyralid. Glyphosate at 0.98 followed-by (fb) 0.98 fb 0.77 lb ae/A gave 58% and 11% waterhemp control at 14 and 48 dat, respectively. Glyphosate plus clopyralid gave similar waterhemp control as glyphosate alone, while glyphosate plus ethofumesate, desmedipham & phenmedipham, or triflusulfuron or glyphosate plus a 2-way combination of these herbicides gave greater waterhemp control than glyphosate alone. However, no POST treatment gave greater than 64% waterhemp control at 48 dat. In the lay-by herbicide trial, sugarbeet injury was negligible from all treatments. Glyphosate at 0.98 fb 0.98 fb 0.77 lb ae/A gave 61% and 35% waterhemp control at 14 and 48 dat, respectively, while glyphosate plus ethofumesate at 0.125 lb/A gave 75% waterhemp control at 48 dat. Glyphosate plus lay-by dimethenamid-p at 0.66 lb ai/A improved waterhemp control compared to glyphosate alone, while glyphosate plus s-metolachlor, or glyphosate plus acetochlor gave similar waterhemp control compared to glyphosate alone. However, waterhemp control was similar from glyphosate plus either dimethenamid-p, s-metolachlor, or acetochlor. The addition of ethofumesate at 0.125 lb/A to tank-mixes of glyphosate plus a lay-by herbicide increased waterhemp control 35 to 50% compared to glyphosate plus the lay-by herbicide without ethofumesate. In the PPI and PRE herbicide trial, sugarbeet stand was counted in the center two rows 24 days after planting. Sugarbeet stand was reduced from PRE s-metolachlor at 1.91 lb/A and s-metolachlor at 0.95 lb/A plus ethofumesate compared to when no soil herbicide was applied. Waterhemp control on August 27 (48 days after POST treatments) from glyphosate at 0.98 fb 0.98 fb 0.77 lb ae/A was 33%. All PPI or PRE treatments increased waterhemp control compared to glyphosate and ranged from 70 to 100%. Ethofumesate alone at 3 lb/A, whether applied PPI or PRE, gave less control than treatments containing s-metolachlor. At Prosper, ND s-metolachlor and ethofumesate were applied PRE both singly and in combination and fb glyphosate alone or glyphosate plus dimenthenamid-p to evaluate their effects on sugarbeet injury, yield and quality. The greatest reduction to stand both 30 and 100 days after planting was from PRE s-metolachlor at 1.43 lb/A. Sugarbeet treated with PRE ethofumesate, either alone or in combination, gave greater injury following application of glyphosate plus dimethenamid-p compared to glyphosate alone. Sugarbeet treated with PRE s-metolachlor alone gave similar injury following application of glyphosate alone or glyphosate plus dimethenamid-p. No differences in yield or sugar content were observed.

APPLICATION BEST MANAGEMENT PRACTICES FOR BALANCING DRIFT MITIGATION AND WEED CONTROL WITH THE ENLIST WEED CONTROL SYSTEM. Andy Asbury*[1], Patrick Havens[2], David E. Hillger[3], Ryan Keller[4], John Laffey[5], Ralph Lassiter[6], Jerome Schleier[2], Jonathan Siebert[7]; [1]Dow AgroSciences, Dahinda, IL, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Noblesville, IN, [4]Dow AgroSciences, Rochester, MN, [5]Dow AgroSciences, Maryville, MO, [6]Dow AgroSciences, Raleigh, NC, [7]Dow AgroSciences, Greenville, MS (165)

Dow AgroSciences has developed the Enlist™ Weed Control System, breakthrough weed control technology that advances herbicide and trait technology by building on the Roundup Ready® system. The Enlist system will help control herbicide-resistant and hard-to-control weed populations. Enlist traits give corn, soybeans and cotton tolerance to Enlist Duo™ herbicide in the same application window as Roundup® herbicide. Enlist Duo herbicide is a proprietary blend of glyphosate and a new 2,4-D choline. Just as important as the trait and herbicide, Enlist™ Ahead is a benefits-based management resource that helps growers get the best results from the Enlist system—today and in the future. Built on a three-pillar foundation, Enlist Ahead will offer farmers, applicators and retailers management recommendations and resources, education and training, and technology advancements. The label and best management practices for applying Enlist Duo herbicide address application parameters, the impact of weather conditions, weed resistance management and proper tank cleanout. These requirements represent several years of research aimed at reducing the potential for off-target movement of Enlist Duo herbicide. Dow AgroSciences has used the latest science and technology to address problem weeds, and Enlist will be a very effective solution.

INFLUENCE OF NOZZLE TYPE AND WIND SPEED ON SOYBEAN INJURY FROM DICAMBA APPLICATIONS. Ryan S. Henry*[1], Cody F. Creech[1], Sanela Milenkovic[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (166)

No abstract submitted

INFLUENCE OF NOZZLE TYPE AND WIND SPEED ON COTTON INJURY FROM DICAMBA APPLICATIONS. Ryan S. Henry*[1], Cody F. Creech[1], Sanela Milenkovic[1], William E. Bagley[2], Greg R. Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]University of Nebraska-Lincoln, USA, Lincoln, NE (167)

No abstract submitted

IMPLICATIONS OF DRIFT STUDIES ON THE APPLICATION OF HERBICIDES: A REVIEW OF WHAT WE HAVE LEARNED. Greg R. Kruger*[1], Ryan S. Henry[2], William E. Bagley[3]; [1]University of Nebraska-Lincoln, USA, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Bagley Enterprises, San Antonio, TX (168)

Drift is a problem with every pesticide application that is sprayed through a nozzle. Drift incidences can vary in severity and have started to threaten our industry. Making sure that applications are made in as clean of a way as possible is critical to the long-term acceptance of pesticide use in the US. Applicators need to consider many things in order to mitigate drift. Among these are wind speed, wind direction, nearest sensitive species, boom height and droplet size. While applicators cannot control what the wind speed, wind direction and how close sensitive species are to the field, they have control over boom height and droplet size. Over the past three years, the Pesticide Application Technology Laboratory at the West Central Research and Extension Center in North Platte, NE has conducted a significant number of research trials to understand how to best apply herbicides while mitigating off-target movement, particularly physical particle drift. We have shown that there are significant gains to be made in terms of how we apply herbicides to both improve efficacy as well as mitigate unintended effects. We have found that off-target movement is more complex than simply understanding droplet size though. Factors such as droplet vector and velocity can also play an important role in droplet deposition and drift. As we move into an era with sensitive equipment that can pick up extremely low rates of pesticide and we start using products in-season that take very low rates to cause visual symptomology, it is going to be imperative that both the applicators and the industry do everything they can to prevent drift.

ASSESSMENT OF DRIFT REDUCTION TECHNOLOGIES AND PULSE WIDTH MODULATION FOR DICAMBA-GLYPHOSATE APPLICATIONS ON GLYPHOSATE RESISTANT WATERHEMP. Scott M. Bretthauer*[1], Robert E. Wolf[2], Matthew P. Gill[1]; [1]University of Illinois, Urbana, IL, [2]Wolf Consulting and Research, Mahomet, IL (169)

No abstract submitted

ATOMIZATION OF AGRICULTURAL TANK MIXTURES USING A PULSE WIDTH MODULATION SPRAY DELIVERY SYSTEM: PART II. Lillian C. Magidow*[1], Stephanie Wedryk[2]; [1]Winfield Solutions, River Falls, WI, [2]Winfield Solutions, St. Paul, MN (170)

The share of pesticide applicators using pulse width modulation (PWM) systems has shown rapid and consistent growth for many years. These systems manage flow rate using a solenoid valve at each nozzle, which pulses at a constant rate (typically 10 Hz) while varying the time the valve stays open for each pulse. Unlike a typical rate controller, spray pressure remains constant as the user changes speed. According to manufacturer claims, PWM systems do not alter droplet size distribution. To test this claim, three pesticide formulations and two tank mix drift control adjuvants (oil emulsion and polyacrylamide) were sprayed through conventional and PWM systems within a low-speed wind tunnel. Droplet size distribution was measured using a laser diffraction sensor. The proportion of fine droplets (<210 μm) decreased slightly with PWM, while the proportion of ultra-coarse droplets (>730 μm) increased significantly. The polyacrylamide adjuvant decreased fine droplets more than the oil emulsion adjuvant, but also increased ultra-coarse droplets dramatically, to >60% of spray volume in some cases. Ultra-coarse droplets have the potential to reduce pesticide coverage on the target, which can lead to decreased weed control with some products, exacerbating herbicide resistance issues. Among the combinations tested, the proportion of ultra-coarse droplets was greatest with the polyacrylamide and PWM combined. The increase in coarse droplets with PWM may be due to residual liquid adhering to the nozzle between pulses. PWM systems can provide excellent reduction in drift potential. Risk of pesticide drift can be further diminished with drift reduction adjuvants, but oil emulsion technology appears more suitable than polymer technology for balancing drift reduction and coverage with PWM systems.

LAESI-MS IN THE DETERMINATION OF 2,4-DICHLOROPHENOXYACETIC ACID IN PLANT TISSUE. Gregory J. Lindner*[1], Stephen Rumbelow[2], Holly Henderson[3], Melissa Moury[3], Haddon Goodman[3], Thomas Steen[1]; [1]Croda Inc, New Castle, DE, [2]Croda Inc, Wilmington, DE, [3]Protea Biosciences, Morgantown, WV (171)

Laser ablation electrospray ionization mass spectrometry imaging (LAESI-MSI) was used to investigate the influence of an agrochemical adjuvant on the spatial distribution of a commercial herbicide (2,4-D) when applied as aqueous droplets to the surfaces of poinsettia and cabbage leaves. This ambient technique enabled both 2D and 3D molecular images to be generated, illustrating that the addition of the adjuvant resulted in greater coverage of leaf surface area, a more even distribution, and considerably enhanced permeation of the active into the leaf. Further investigations clearly demonstrated that the adjuvant greatly enhanced the permeation of the 2,4-D into the leaf even after relatively short exposure times (2-8 hr) and that the distribution pattern formed on the surface was effectively replicated down through the various leaf layers. Studies were also performed to demonstrate whether the presence of adjuvant affected retention of the active on the leaf surface. The results of associated rinse-off studies conducted to provide a comparative adjuvant medikated uptake quantitation technique are presented which support the LAESI-MS results.

GLUFOSINATE EFFICACY WITH TANK-MIX PARTNERS AND DROPLET SIZE. Kirk A. Howatt*[1], Rich Zollinger[2]; [1]NDSU, Fargo, ND, [2]North Dakota State University, Fargo, ND (172)

The threat and reality of glyphosate-resistant weed biotypes is promoting interest in glufosinate-resistant crops. This especially is true for weed control in soybean because control of several broadleaf weeds can be difficult with existing chemistries. Evaluating weed control for glufosiante-based programs where large spray droplet size is desired to mitigate particle drift is important because large droplets may not provide as much coverage of leaf area compared to previous research protocol. Three trials have demonstrated control with glufosinate in coarse or very coarse droplet size generally to be equal to or better than control when applied in fine and medium droplets. Two of these studies with prescribed spray volume differences showed greater control with more water volume from 5 to 20 gpa, with 10 and 15 gpa providing generally similar control. In the third study, glufosinate provided exceptional and similar weed control across most species present regardless of tank-mix partner or droplet size. However, yellow foxtail control at the margin of the spray pattern was as much as 10 percentage points greater with medium to coarse droplets than with very to extremely coarse droplets. Addition of clethodim did not improve yellow foxtail control, but 2,4-D or dicamba did not antagonize glufosinate efficacy either. Also in this study, 2,4-D or dicamba provided residual activity against broadleaf weeds that resulted in 65 to 99% control at mid-August evaluation in plots without crop canopy.

AMMONIUM SULFATE REPLACEMENT ADJUVANTS - PART 3. Rich Zollinger*[1], Kirk Howatt[1], Bryan Young[2], Mark Bernards[3]; [1]North Dakota State University, Fargo, ND, [2]Purdue University, W. Lafayette, IN, [3]Western Illinois University, Macomb, IL (173)

Glyphosate and dicamba are weak acid herbicides and can bind with antagonistic salts in the spray carrier. Diammonium sulfate (AMS) is commonly used as an adjuvant with glyphosate to enhance activity and overcome antagonistic salts. AMS will be restricted from use with dicamba in dicamba resistant soybean due to increasing dicamba volatility and resulting increases in risk of off-site movement. Di-potassium phosphate (DPP) as a substitute for AMS does not contain nitrogen and does not influence dicamba vapor pressure. DPP can partially overcome antagonism from minerals in the spray solution but is ineffective in reducing dicamba antagonism of clethodim. The margin of separation was greater on species that are particularly responsive to AMS in hard water. The herbicide moiety that conditions water is sulfate and phosphate. In addition to water conditioning properties of sulfate, ammonium in AMS increases herbicide absorption and translocation. The positively charged potassium from DPP is a weak herbicide antagonist and even at low amounts may reduce herbicide efficacy. As DPP may condition water through the phosphate anion the compound is void of nitrogen which may explain why DPP does not exhibit the same level weak-acid herbicide enhancement and of overcoming mineral and herbicide antagonism as AMS.

WEED MANAGEMENT IN STRIP TILLAGE. Erin Haramoto*[1], Daniel Brainard[2]; [1]University of Kentucky, Lexington, KY, [2]Michigan State University, East Lansing, MI (174)

Combining strip tillage (ST), a form of reduced tillage, with deep nitrogen (N) fertilizer banding has the potential to improve crop N uptake and reduce the amount of N available for uptake by weeds. Relative strip placement in long-term ST (i.e. whether tilled strips are located in the same position from year to year or whether their location is offset) can influence nutrient release, residue management, and soil quality—all factors that can also influence weed dynamics. Systems-level field experiments were conducted to determine how deep N banding combined with ST affected weed density and biomass in a sweet corn / cabbage rotation. Treatments included ST with strips located in the same position from year to year (ST same), ST with strip location offset from year to year (ST offset), and full-width tillage (FWT). In both ST treatments, all N was applied in the crop row (IR); initial N applications were broadcast in FWT so between 50-75% of N was applied to the IR zone. Two weed management intensities were also examined—just herbicides (low intensity) and herbicides plus a hand-weeding pass (high intensity). We expected to find lower weed biomass in ST with deep fertilizer banding in both zones—in the between row (BR) zone because no fertilizer was applied to this zone and in the IR zone because fertilizer was applied deeper where the larger-rooted crop plants would be more likely to access it first. We also expected to find improved crop growth and lower weed biomass in ST offset as we hypothesized that nutrients mineralized from soil organic matter would benefit the crop plants before weeds. As expected, in cabbage, ST resulted in lower final weed biomass than CT in the BR zone in both years. This was not observed in sweet corn—no tillage effects were detected in either zone in 2012 and ST offset had higher BR weed biomass than both CT and ST same with low intensity weed management in 2013. ST same was also associated with higher BR weed biomass than ST offset and CT following high intensity management in 2013. IR weed biomass was typically lower than BR weed biomass, likely due to increased crop competition. In the IR zone, tillage either had no effect (both crops in 2012) or ST offset had higher weed biomass than CT and ST same (both crops in 2013). These results suggest that ST with fertilizer banding can differentially impact BR weeds depending on the crop. For cabbage, a less competitive crop in which canopy closure does not occur when grown on 76 cm row spacing, ST with fertilizer banding can contribute to weed management in the BR zone. Relative strip placement influenced BR weeds in sweet corn and IR weeds in both crops in 2013. In two of these three cases, ST offset was associated with greater weed biomass than CT and ST same. This treatment also had greater sweet corn yield relative to CT in 2013, suggesting that improved N release that may have occurred favored both sweet corn and weeds.

IMPACT OF PRE+POST VS. POST-ONLY WEED MANAGEMENT STRATEGY ON N_2O EMISSIONS. Rebecca R. Bailey*, Vince M. Davis; University of Wisconsin-Madison, Madison, WI (175)

Nitrous oxide (N_2O) is a potent greenhouse gas with implication for contributing to global warming effects. Emissions increase as available soil nitrate, soil moisture, carbon availability, and soil temperature increase. In the absence of preemergence (PRE) herbicides, weeds compete with crops and reduce soil nitrate and moisture levels, which may reduce N_2O emissions relative to a weed-free environment. However, once weeds are terminated with postemergence (POST) herbicides, emissions may increase as the weeds supply carbon to microbial denitrifiers. To determine this relationship, three non-crop greenhouse studies, two non-crop field studies, four corn studies, and two soybean studies were conducted in 2013 and 2014 to compare the effects of PRE + POST and POST-only weed management strategies on N_2O emissions before and after weed termination. All studies included this main effect of weed management, which was combined in a factorial treatment structure with nitrogen (N) rates of 0 or 200 kg N ha^{-1} (non-crop greenhouse), 0 or 225 kg N ha^{-1} (non-crop field), and 0, 90, or 180 kg N ha^{-1} (corn), or row widths of 38- or 76-cm (soybean). PRE herbicides and N were applied at the time of planting, and POST applications were made when weeds were 10-15 cm tall. N_2O emissions were measured from gas samples collected weekly from static chambers placed within each plot from the time of planting until four weeks after POST application in the non-crop studies and until mid-September in the corn and soybean studies. Data were compared separately for each set of studies in SAS 9.3 using mixed a model with main factors and their interaction as fixed effects and environments as random effects. Means were separated using Fisher's protected LSD at $\alpha = 0.05$. N_2O emissions were not influenced by *weed*N* in the non-crop greenhouse, non-crop field, or corn studies (p=0.0927, p=0.4359, and p=0.8800, respectively), but higher N rates led to increased N_2O emissions ($p<0.0001$) in all studies. In the soybean study, neither *width* (p=0.8592) nor *weed*width* (p=0.5955) had a significant impact on N_2O fluxes. In the greenhouse studies, emissions after termination were higher in treatments with weeds than those without (2.6 vs. 1.3 mg N_2O-N m^{-2}, p=0.0003), and overall emissions were higher for the POST-only treatments (p=0.0003). At the field-scale, POST-only treatments had lower emissions than PRE + POST treatments before termination in the soybean study, but weed management did not influence N_2O emissions from the non-crop field, corn, or soybean studies for any other measurement period at $\alpha = 0.05$. Corn yield was 13.2 vs. 12.1 Mg ha^{-1} ($p<0.0001$) when a PRE was used vs. when it was not, and soybean yield was also significantly higher in the PRE + POST vs. POST-only management system (4270 vs. 3620 kg ha^{-1}, respectively, p=0.0007). In summary, an impact of weeds on N_2O emissions was detectable in the greenhouse and soybean studies. Although season-long N_2O emissions were comparable for both PRE + POST and POST-only weed management strategies in the corn and soybean systems, use of a PRE herbicide was still important for increased yield.

IMPACT OF WATERHEMP EMERGENCE DATE ON GROWTH AND DEVELOPMENT OF FIVE POPULATIONS IN INDIANA. Joseph M. Heneghan*[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (176)

Waterhemp (*Amaranthus tuberculatus* var. *rudis*) exhibits discontinuous germination which can influence biomass accumulation and plant height. Two field experiments were conducted to investigate the timing of waterhemp emergence and the associated difference in end-of-season height and biomass accumulations as well as in-season growth rate. Native waterhemp emergence was monitored within 1 m^2 plots from March through October with three tillage treatments consisting of no tillage, one soil disturbance and two soil disturbance events during the growing season. Emerged waterhemp was counted and removed weekly while precipitation, air and soil temperature at 3 cm was recorded. Peak emergence was observed during the last 14 days of May with emergence spanning from April to August. In a separate experiment, waterhemp from Indiana, Illinois, Missouri, Iowa and Nebraska was initiated in the greenhouse and later transplanted into a common garden at three different timings to simulate discontinuous germination. The three greenhouse planting dates were May 12, June 2, and July 14 with plants transplanted to the field 12-15 days after initiation. Weekly height measurements were taken from 12 plants in every plot and end of season biomass accumulation was measured. Across all planting dates, the Indiana population was observed to exhibit rapid early-season growth. The Illinois population consistently exhibited the greatest late-season growth rate while the Iowa and Nebraska populations were consistently the lowest growth rate. The Indiana and Missouri populations were most similar throughout the duration of the experiment. A definitive trend between in-season growth rate and end-of-season height and biomass accumulation was only observed in the July 14 planting. Overall, biomass and plant height decreased as plants were established later in the growing season.

WEED CONTROL IN EDAMAME. Bernard H. Zandstra*, Colin J. Phillippo; Michigan State University, East Lansing, MI (177)

Edamame (*Glycine max* (L.) Merr.), also called edible soybean, has been an important vegetable crop in the Orient for many years. Edamame consumption in the USA has increased in recent years because of its versatile use and high nutritional content. The immature beans eaten as a vegetable may contain up to 20% fat and 15% protein. The immature pods are harvested 70-90 days after seeding. In addition to use as a fresh vegetable, edamame is used to make soymilk, tofu, miso, and soy sauce. The seeds are germinated for soybean sprouts. The beans also can be roasted and salted and eaten as a snack. For fresh consumption, edamame is cooked in the pods in salt water until the beans are tender. Diners squeeze the beans out of the pods directly into their mouths. Edamame is included in Crop Group 6 (edible legumes) for which green bean, pea, and soybean are the representative crops. However, there is minimal data on edamame tolerance to many herbicides, so very few herbicides have been labeled for use on the crop. Herbicide trials were conducted to evaluate pre and postemergence herbicides for weed control in edamame. Edamame was somewhat sensitive to most preemergence herbicides. In most cases, it outgrew early stunting. Clomazone and s-metolachlor caused the least early stunting. By harvest, edamame had outgrown most early stunting and yields were not reduced. Herbicides producing good yields included clomazone, flumioxazin, s-metolachlor, pyroxasulfone, and sulfentrazone. In postemergence treatments, aciflurofen caused early stunting and yield reduction. Imazamox, bentazon, and fomesafen did not reduce yield. Several herbicides were labeled for edamame during 2014, including fomesafen, linuron, and s-metolachlor. Labels for other herbicides are being developed.

WEED CONTROL IN VEGETABLE CROPS WITH BICYCLOPYRONE. Colin J. Phillippo*, Bernard H. Zandstra; Michigan State University, East Lansing, MI (178)

Bicyclopyrone is a new herbicide which inhibits 4-HPPD (HRAC Group F2, WSSA 27). It prevents pigment formation in susceptible plants, which causes plant bleaching. Bicyclopyrone will be labeled in 2015 as a combination product for use in corn. Bicyclopyrone was evaluated for vegetable and herb crop weed control in several locations in Michigan and one location in Illinois. Bicyclopyrone was applied at rates of 0.033 and 0.045 lb ai/a in preemergence and postemergence applications. When applied preemergence, it was safe on asparagus, carrot, cilantro, and onion, but caused moderate injury to established chives and pumpkin. It caused unacceptable crop injury on lettuce, seeded chives, green onions, winter squash, spearmint, basil, dill, fennel, and parsley. When applied pre-transplant, it was safe on cabbage and Chinese cabbage, but caused significant injury to peppers and tomatoes. Postemergence bicyclopyrone application was safe on broccoli, cabbage, and carrot. It caused significant injury to Chinese cabbage, basil and carrots. All crops treated with bicylopyrone post-transplant were injured significantly, including banana pepper, jalapeno pepper, broccoli, cabbage, Chinese cabbage, and celery. Bicyclopyrone was more effective than mesotrione against annual grasses. Preemergence and postemergence bicyclopyrone treatments controlled barnyardgrass (*Echinochloa crus-galli*), green foxtail (*Setaria viridis*), and large crabgrass (*Digitaria sanguinalis*) (pre only), but had little effect on field sandbur (*Cenchrus incertus*). Bicyclopyrone exhibited excellent preemergence and postemergence control of common lambsquarters (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*), Eastern black nightshade (*Solanum ptycanthum*), and redroot pigweed (*Amaranthus retroflexus*), but it did not control common purslane (*Portulaca oleracea*). Ladysthumb (*Polygonum persicaria*) was controlled preemergence by bicyclopyrone on mineral soil but not on organic soil. Ladysthumb was controlled well postemergence on both soil types. Bicyclopyrone may be an effective herbicide for annual grass and broadleaf control programs in several vegetable crops. Further research is needed to determine the influence of soil type on bicyclopyrone efficacy.

DOES HETEROZYGOSITY OF HERBICIDE-RESISTANCE TRAITS DESERVE GREATER ATTENTION FROM WEED SCIENTISTS? A CASE STUDY FROM RESISTANCE TO PPO INHIBITORS. R. Joseph Wuerffel*[1], Bryan Young[2]; [1]Southern Illinois University, Carbondale, IL, [2]Purdue University, W. Lafayette, IN (179)

The principle of Hardy-Weinberg equilibrium (HWE) asserts that allelic and genotypic frequencies will remain in a predictable equilibrium if evolutionary selection pressures are limited. Agrestal weed populations under intense anthropogenic selection pressure from annual herbicide applications will undoubtedly deviate from HWE via an excess or a lack of heterozygous individuals; however, deviation from HWE and the frequency of heterozygosity has not been thoroughly described in herbicide-resistant weed biotypes. Evolved resistance to protoporphyrinogen oxidase (PPO)-inhibiting herbicides (PPO-R) in waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer (syn. *rudis*)] provides an ideal model to investigate deviation from HWE. Waterhemp is dioecious (self-incompatible) and resistance to PPO inhibitors is inherited from a single resistance (R)-allele that reportedly displays incomplete dominance. Altogether, this suggests there should be an abundance of individuals heterozygous for resistance to PPO-inhibitors; however, there is limited data available to qualify this assertion. To investigate the frequency of heterozygosity in multiple, endemic waterhemp populations, soil seed bank samples were collected from 13 fields containing waterhemp that survived a foliar-applied PPO-inhibiting herbicide in 2013. A minimum of 120 plants from each population were genotyped to calculate the inbreeding coefficient (F_{is}) of each population, which represents the fractional reduction in heterozygosity compared to the heterozygosity that would be expected under HWE. If a population is in HWE, F_{is} will equal zero; conversely, deviation from HWE via a lack or an excess of heterozygosity will be represented by positive or negative F_{is} values as inbreeding becomes more or less frequent than expected, respectively. In the present study, all F_{is} values were positive and ranged from 0.45 to 0.90, indicating a clear lack of heterozygosity in the PPO-R waterhemp complex. Overall, waterhemp heterozygous for PPO-R was largely found to have PPO inhibitor sensitivity similar to that of the homozygous-resistant individuals, with the exception of two populations, indicating targeted control of heterozygous PPO-R waterhemp is likely not a viable management strategy. Nevertheless, genotypic frequencies should be explored in other herbicide-resistance systems, particularly those where heterozygous individuals may be controlled with typical field use rates (i.e. low-level herbicide resistance and recessive resistance traits). In such a system, cross-pollination with herbicide-susceptible individuals could diffuse the R-allele into heterozygous condition in the progeny; subsequently, heterozygous progeny could be managed the following year. Overall, quantifying the frequency of heterozygous individuals in herbicide-resistant weed populations has the potential to provide valuable information for applied herbicide-resistance management recommendations and, therefore, deserves consideration for further experimentation.

AN UPDATE ON HPPD-RESISTANCE IN AMAPA AND AMATA POPULATIONS. Vinod K. Shivrain*[1], Cheryl L. Dunne[2], Gordon Vail[1]; [1]Syngenta, Greensboro, NC, [2]Syngenta, Vero Beach, FL (180)

HPPD-inhibitor herbicides have been very effective as preemergence and postemergence treatments for weed management in corn. Resistance to postemergence applied HPPD-inhibitors has recently been documented in waterhemp (*Amaranthus tuberculatus* - AMATA) and Palmer amaranth (*Amaranthus palmeri* - AMAPA). Greenhouse studies were conducted to determine the levels of HPPD resistance in these AMATA and AMAPA biotypes. In addition, response of AMATA and AMAPA accessions obtained from various states in the mid-west and mid-south, respectively, to mesotrione applied postemergence at 3- and 6-inch height of plants was also investigated in the greenhouse. Significant differences in control were observed between these accessions treated at the same rate of mesotrione. Also, the control for all accessions in all treatments decreased significantly when the applications were made to 6 inch versus 3 inch plants. The variability in control of various accessions at the same rate of herbicide indicates that there are inherent differences in the sensitivity of AMATA and AMAPA populations to HPPD herbicides with respect to both origin and height at the time of treatment. These data clearly suggest that mesotrione is most effective and consistent in controlling sensitive AMATA and AMAPA populations when applied to smaller (up to 3 inch) plants.

MOLECULAR ANALYSIS OF GLYPHOSATE RESISTANCE IN GIANT RAGWEED. Karthik Ramaswamy Padmanabhan*[1], Kabelo Segobye[2], Michael Gribskov[1], Burkhard Schulz[1], Stephen C. Weller[1]; [1]Purdue University, West Lafayette, IN, [2]Botswana College of Agriculture, Gaborone, Botswana (181)

Giant ragweed is one of the most competitive annual weeds in corn and soybean production across the eastern Corn Belt in the United States. The use of glyphosate (commercial name: Roundup) and glyphosate-resistant crop systems were effective in managing giant ragweed populations for several years. However, in the last decade, glyphosate-resistant giant ragweed has been reported in the eastern cornbelt and Canada resulting in a huge problem to farmers and requiring use of additional preemergence and postemergence herbicides for acceptable control in order to avoid yield loss. The research reported here has the goal to identify the genes responsible for conferring glyphosate resistance. Both glyphosate-resistant and glyphosate-sensitive biotypes of giant ragweed were studied using a RNA-seq experiment. Total mRNA was extracted from leaf disks of untreated and glyphosate treated leaves over a time-course of 0 to 6 hours after herbicide application and the transcriptome of sensitive and resistant giant ragweed biotypes were compared. We have identified a list of genes that were differentially expressed between the two biotypes as the first step in eventually identifying genes responsible for the glyphosate resistance observed.

SUSCEPTIBILITY OF MULTIPLE KOCHIA (KOCHIA SCOPARIA) POPULATIONS TO DICAMBA. David A. Brachtenbach*[1], Phillip W. Stahlman[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hays, KS (182)

Kochia [*Kochia scoparia* (L.) Schrad] has become highly problematic throughout the Great Plains of North America as a result of evolving resistance to multiple herbicide mechanisms of action. Commercialization of soybeans and cotton with tolerance to dicamba is anticipated in 2015, pending regulatory approval. Widespread adoption of this technology likely will increase dicamba use and selection pressure on weed populations. The objective of this research was to determine whether various kochia populations from the central Great Plains differ in susceptibility to postemergence-applied dicamba. Greenhouse-grown plants from 34 populations were sprayed with 420 g ae ha^{-1} of dicamba and the populations were categorized from least to most susceptible based on aboveground biomass and plant mortality ratings 5 weeks after treatment (WAT). Eleven populations representing the least, moderately, and most susceptible populations from the initial screening were selected to perform a dicamba dose-response experiment. Aboveground biomass (both fresh and dry matter), plant morality, and visual growth reduction estimates were recorded 4 WAT. Results for fresh and dry biomass were similar and GR_{50} values (doses required to reduce biomass by 50%) indicated at least a 7-fold difference among the populations in susceptibility to dicamba applied postemergence. The GR_{50} dose for the least susceptible population was approximately 820 g ae ha^{-1} and plant morality of that population was less than 20% at 2240 g ae ha^{-1}. Evidence of differential susceptibility to dicamba in the kochia populations studied suggests the need for strong stewardship recommendations for dicamba use and diverse management practices to prevent further evolution of kochia resistance to dicamba.

CONTROL OF GLYPHOSATE-RESISTANT COMMON WATERHEMP IN GLUFOSINATE-RESISTANT SOYBEAN. Amit J. Jhala*[1], Lowell D. Sandell[2], Debalin Sarangi[3]; [1]University of Nebraska-Lincoln, USA, Lincoln, NE, [2]Valent USA Corporation, Lincoln, NE, [3]University of Nebraska-Lincoln, Lincoln, NE (183)

Glyphosate-resistant common waterhemp (*Amaranthus rudis* Sauer) is the most difficult-to-control weed species in midwestern United States, especially for soybean growers due to limited effective postemergence (POST) herbicide options. Commercialization of glufosinate-tolerant soybean, an alternative for glyphosate-resistant crop technology, allows growers to apply glufosinate in-crop for broad-spectrum weed control, including control of glyphosate-resistant weeds. Field experiments were conducted in Dodge County, NE in 2013 and 2014 to evaluate herbicide programs for control of glyphosate-resistant common waterhemp in glufosinate-resistant soybean. Results revealed that all the preemergence (PRE) herbicides provided ≥76% control of glyphosate-resistant common waterhemp and reduced density to ≤34 plants m^{-2} at 14 days after treatment. Glufosinate applied sequentially at 594 g ai ha^{-1} resulted in 76% control of glyphosate-resistant common waterhemp at 42 days after planting (DAP); however, control was reduced to 4% at harvest and soybean yield was only 1,136 kg ha^{-1}. Herbicide programs including chlorimuron plus thifensulfuron plus flumioxazin, *S*-metolachlor plus fomesafen, *S*-metolachlor plus metribuzin, sulfentrazone plus metribuzin, or saflufenacil plus dimethenamid-P applied PRE followed by glufosinate provided ≥ 91% control of glyphosate-resistant common waterhemp throughout the season and resulted in higher soybean yield (≥ 1,810 kg ha^{-1}). It is concluded based on results of this study that herbicide programs are available for control of glyphosate-resistant common waterhemp in glufosinate-resistant soybean.

ENLIST AHEAD APP: MANAGEMENT RESOURCES FOR THE ENLIST WEED CONTROL SYSTEM. David E. Hillger*[1], Andy Asbury[2], Ryan Keller[3], John Laffey[4], Ralph Lassiter[5], Jonathan Siebert[6], Jake Wiltrout[7]; [1]Dow AgroSciences, Noblesville, IN, [2]Dow AgroSciences, Dahinda, IL, [3]Dow AgroSciences, Rochester, MN, [4]Dow AgroSciences, Maryville, MO, [5]Dow AgroSciences, Raleigh, NC, [6]Dow AgroSciences, Greenville, MS, [7]Dow AgroSciences, Indianapolis, IN (184)

Dow AgroSciences has developed the Enlist™ Weed Control System, breakthrough weed control technology that advances herbicide and trait technology by building on the Roundup Ready® system. The Enlist system will help control herbicide-resistant and hard-to-control weed populations. Enlist traits give corn, soybeans and cotton tolerance to Enlist Duo™ herbicide in the same application window as Roundup® herbicide. Enlist Duo herbicide is a proprietary blend of glyphosate and a new 2,4-D choline. Just as important as the trait and herbicide, Enlist™ Ahead is a benefits-based management resource that helps growers get the best results from the Enlist system—today and in the future. Built on a three-pillar foundation, Enlist Ahead will offer farmers, applicators and retailers management recommendations and resources, education and training, and technology advancements. As part of the Enlist Ahead program, Dow AgroSciences has developed the Enlist Ahead App. The app, designed for use with the Enlist Weed Control System, is a precision agriculture tool for maximizing weed control performance, managing weed resistance and making responsible applications of Enlist Duo™ herbicide with Colex-D™ Technology. In addition to the label, it offers growers and applicators practical herbicide application information from a single source that they can take with them from field to field. An example of the specific features found within the Enlist Ahead app are an application planner, mode of action calculator and a nozzle selection tool. The app's herbicide application planner combines real-time, localized weather data, capabilities to map crop fields and trait technologies, and other important considerations for growers and applicators to review before making a responsible herbicide application. Dow AgroSciences has used the latest science and technology to address problem weeds, and Enlist will be a very effective solution.

ENLIST 360 EDUCATION SERIES: EDUCATION, TRAINING AND OUTREACH ON THE ENLIST WEED CONTROL SYSTEM. Ryan Keller*[1], Andy Asbury[2], David E. Hillger[3], John Laffey[4], Ralph Lassiter[5], Jonathan Siebert[6], Jake Wiltrout[7]; [1]Dow AgroSciences, Rochester, MN, [2]Dow AgroSciences, Dahinda, IL, [3]Dow AgroSciences, Noblesville, IN, [4]Dow AgroSciences, Maryville, MO, [5]Dow AgroSciences, Raleigh, NC, [6]Dow AgroSciences, Greenville, MS, [7]Dow AgroSciences, Indianapolis, IN (185)

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WHICH BROMOXYNIL SHOULD I USE FOR BROADLEAF WEED CONTROL IN ONION? Harlene M. Hatterman-Valenti*[1], Collin P. Auwarter[2]; [1]North Dakota State University, Fargo, ND, [2]ndsu, fargo, ND (186)

A field study was conducted at the Oakes Irrigation Research Facility near Oakes, North Dakota to compare early-season weed control of bromoxynil (Buctril and Broclean) and oxyfluorfen (GoalTender) applied at micro-rates to standard preemergence treatments of DCPA (Dacthal) and ethofumesate (Nortron) in onion. 'Crocket', 'Patterson', 'Sedona', and 'Talon were planted April 25 with 18" centers and a planting population of 175,000 seeds/A. Preemergence herbicides (1 and 2 lb/A ethofumesate and 13.33 lb/A DCPA were applied 11 days after planting (DAP). Micro-rate applications began when weed seedlings reached the first-true-leaf stage, which coincided with onion between the flag-leaf and one-true-leaf stage, 27 DAP. Bromoxynil and oxyfluorfen were applied at the 0.25 and 0.13 times the lowest labeled rate along with 0.031 lb/A clethodim (Select Max) and applied in four of five sequential applications with a seven day interval. Petroleum oil-surfactant (Herbimax) (1 pt/ac) was tank mixed with the micro-rate applications. All onion plots received bromoxynil (Buctril) at 0.25 lb /A and oxyfluorfen at 0.50 lb/A when onion were at the 5-leaf and 9-leaf stage. Onion injury in the Broclean treatments were 5% greater compared to the Buctril treatments, but all had less than 10% visual injury 37 days after application. ‘Sedona’ average yield was greater than the other three cultivars. When averaged over the four cultivars, only five treatments had marketable yields greater than 450 CWT/A and consisted of two preemergence treatments and three micro-rate treatments. Of the three micro-rate treatments, two were the only treatments with five sequential application timings suggesting that the additional sequential micro-rate application was beneficial. The other micro-rate treatment with an average yield more than 450 CWT/A was Broclean at 0.0625 lb/A applied twice followed by Broclean at 0.0625 lb/A and oxyfluorfen at 0.0625 lb/A applied twice. Onion yields averaged over the four cultivars were greater when bromoxynil and oxyfluorfen were tank-mixed in the micro-rates than when either herbicide was used alone as micro-rates. Onion yield averaged over the four cultivars and three Broclean/Buctril micro-rate treatments indicated that a 29% marketable yield increase occurred when Broclean was used.

RESPONSE OF TOMATO (*SOLANUM LYCOPERSICUM*) TO SUB-LETHAL DOSES OF 2,4-D AND GLYPHOSATE. Mohsen Mohseni Moghadam*, Andrea S. Leiva Soto, Louceline Fleuridor, Roger Downer, Douglas Doohan; The Ohio State University - Ohio Agricultural Research and Development Center, Wooster, OH (187)

Greenhouse experiments were conducted at the Ohio Agricultural Research and Development Center in Wooster, OH in 2014 to evaluate the effect of simulated drift rates of 2,4-D and glyphosate and 2,4-D plus glyphosate on tomato (*Solanum lycopersicum*). Seeds were sowed on April 15 and 25, 2014 and seedlings were transplanted on May 6 and 16, 2014 in 7.5 L pots. Experimental design was randomized complete block with 4 replications and was repeated once. Herbicide treatments were applied using a three nozzle hydraulic boom in a track room with TeeJet 11002 nozzle tips set at 276 kPa delivering 140 L ha^{-1} at a speed of 6.5 km h^{-1}. Applications were made on May 27, 2014, approximately 3 weeks after transplanting, when tomato seedlings were approximately 34.5 cm tall. Treatments included 2,4-D (840 g ae ha^{-1}), glyphosate (840 g ae ha^{-1}), and 2,4-D plus glyphosate mix (840 g ae ha^{-1} + 840 g ae ha^{-1}). Crop injury was assessed visually using the 0-10 linear scale in which 0 indicated no crop injury, and 10 indicated death of crop. Plant heights were taken from the soil line to the growing tip inside the new leaves. Stem diameter was measured at 10 cm above soil level. Number of fruits per raceme and per plant, and total yield per plant were determined. Data was collected at 1, 2, 3, 5, 7, and 9 weeks after treatment (WAT). Initial injury symptoms in plants treated with 2,4-D plus glyphosate mix 1 WAT were 2 and 4 times greater than plants treated with 2,4-D and glyphosate, and 1.3 and 4 times greater than plants treated with 2,4-D and glyphosate 9 WAT, respectively. Herbicide treatments increased plant height, stem diameter, dry weight, and number of racemes and decreased number of fruits per racemes, total number of fruits per plant, and yield. These data indicate that 2,4-D plus glyphosate mix cause more crop injury and yield reduction compared to when herbicides were applied separately.

HERBICIDE SAFETY ON BEARDLESS IRIS SEEDLINGS. John Kaufmann*; Kaufmann Agknowledge, Okemos, MI (188)

The objective was to demonstrate herbicide safety on beardless iris species. From 30-80 pips of 12 beardless iris seedlings from 7 different hybridizers and one bearded iris were evenly distributed and planted during September 2013, in 14 plots (6 X 21 feet). On May 8, 2014, one corm each of 7 gladiolus cultivars were planted in each plot. Herbicides were applied at 2X the typical recommended rate on July 11, and included: trifluralin, dithiopyr, metolachlor, isoxaben, indaziflam, atrazine, simazine, tembotrione, clopyralid, (2,4-D, MCPP & dicamba mix), bromoxynil, clethodim, glufosinate and sulfentrazone. Replication was achieved only by use of multiple seedlings, cultivars and species, and by use of more than one herbicide within a MOA group whenever possible. No injury on any crop occurred with application of mitotic, cellulose or carotenoid inhibitors. As expected, the graminicide did not injure any crops. However, some leaf tip yellowing did occur from triazines on numerous beardless iris seedlings, but appeared safe to the bearded iris and gladiolus cultivars. Hormone herbicides distorted bloom stalks of gladiolus, otherwise, no injury was seen in this study. Bromoxynil resulted in brown spots and/or leaf tips on nearly all crops. Sulfentrazone resulted in slight leaf burn on several beardless seedlings. Glufosinated appeared to kill everything. All iris species will be monitored next spring for further injury.

INVASIVE SPECIES WEED SEED VIABILITY AFTER COMPOSTING. Mark J. Renz*[1], Joe Van Rossum[2]; [1]University of Wisconsin Madison, Madison, WI, [2]University of Wisconsin Extension, Madison, WI (189)

Composting is a common practice for management of herbaceous yard materials and other decomposable materials. While composting is promoted by state agencies for many materials a notable exception is the exclusion of plant debris from the removal of invasive plant species. This study measured the viability of seeds of garlic mustard and common buckthorn exposed to turned windrow or static composting. Compost piles were constructed and managed for either 120 or 30 days in 2012 or 2013 respectively. Regardless of year of composting or method seed viability was reduced to zero within 7 days for garlic mustard and within 15 days for common buckthorn. To ensure that temperatures observed in the experiment were similar to composting facilities temperature was monitored within research compost piles and compared to those at six licensed Wisconsin compost facilities in 2013. Temperatures were found to be higher at four compost facilities and equal at the other two compared to research trials. This suggests that results may be similar or enhanced at composting facilities compared to our research results. As composting time at facilities are typically greater than six months, our results suggest that composting is a viable option for rendering the seeds of these invasive plants nonviable.

GLYPHOSATE-RESISTANT *CONYZA CANADENSIS* [L.] CRONQ. AND *AMBROSIA TRIFIDA* L. IN ONTARIO: CONTROL FOR BALANCE GT SOYBEANS. Scott Ditschun*; University of Guelph, Guelph, ON (190)

Improved strategies are needed for the control of glyphosate-resistant (GR) Canada fleabane (*Conyza canadensis* [L.] Cronq.) in Ontario soybean (*Glycine max* [L.] Merr.) fields. With the pending release of isoxaflutole resistant (Balance GT) soybean cultivars, a possible strategy will be the combination of glyphosate (GLY) plus metribuzin (MTZ) and isoxaflutole (IFT). Five field trials conducted over a two-year period (2013, 2014) to determine the efficacy of GLY (900 g ae/ha) plus MTZ and IFT at a 4 to 1 ratio for the control of GR Canada fleabane. GLY plus MTZ or GLY plus IFT provided poor control of GR Canada fleabane. GLY plus MTZ and IFT at 210+52.5, 316+79, and 420+105 g ai/ha provided 63, 74 and 85% control of Canada fleabane, respectively. A dose response synergism was observed when MTZ and IFT were applied as a tankmix, while each product applied alone with GLY provided poor control of GR Canada fleabane. Controlled environment factorial experiments were conducted to assess the effect of GLY plus IFT tank mixes and determine the effect of MTZ addition. Antagonism was observed with the GLY plus IFT tankmix, however, when there was a synergistic response when MTZ was added.

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

Indigobush (*Amorpha fruticosa* L.) is a native, deciduous shrub belonging to the Fabaceae family. The leaves are pinnately compound with 11-25 leaflets. The species grows 1 to 3 m tall and is commonly found on wet ground near rivers, streams, and ponds, but may grow on dry upland soils. Indigobush is found throughout most of the continental U.S. and eastern Canada. A study was conducted in Morris County, Kansas during 2013 on an Irwin silty clay loam soil. Nine herbicide treatments plus an untreated check were established on June 18 and October 7. Plots were 3 x 9 m with treatments replicated three times in a randomized block design. Herbicides were applied with a backpack sprayer in about 467 L ha^{-1} spray solutions. A non-ionic surfactant at 0.25% was added to each foliar treatment. Mortality was determined 1 year after treatment with data analyzed using analysis of variance and means separated at the $p<0.05$ level of significance. Herbicides applied included aminocyclopyrachlor + 2,4-D, aminocyclopyrachlor + metsulfuron, aminocyclopyrachlor + triclopyr, triclopyr + fluroxypyr, aminopyralid, and aminopyralid + metsulfuron. Herbicides applied on June 18 were either more effective or equal to the same treatments applied on October 7. Average mortality was 79% from June applications and 66% from October treatments. Aminopyralid + metsulfuron (121 + 22 g ha^{-1}) was more effective on June 18. Aminocyclopyrachlor + triclopyr (140 + 280 g ha-1) was the only treatment to provide greater than 90% mortality of indigobush on both dates of application. All herbicides used in this study provided greater than 50% mortality of indigobush evaluated 1 year after treatment.

VEGETATION MANAGEMENT OPTIONS UNDER CABLE BARRIERS. Joe Omielan*; University of Kentucky, Lexington, KY (192)

Median cable barriers are designed to protect drivers from crossover accidents on interstates and highways. However, the vegetation under and adjacent to them must be managed for safety and aesthetics. Usually that means maintaining a vegetation free zone underneath them but there may be adjacent turf which should not be damaged. In some cases there may be turf under the cable barriers which is being managed. Applications of broad spectrum residual herbicides have become the mainstay for bareground maintenance operations in combination with a broad spectrum postemergent herbicide like glyphosate. One should choose products which are less likely to move to and damage the adjacent turf. With turf under the barriers one would choose mixes for postemerge broadleaf control and preemerge control for broadleaves and annual grasses. This trial evaluates the efficacy and damage potential of some herbicides and mixtures used for vegetation management. The trial was established under and beside cable barrier, with turf underneath, in the median of I-265 in Louisville, KY. The 15 treatments and 3 replications were arranged in a randomized complete block design. Treatments were applied at 234 L/ha onto 2 m by 6 m plots on May 8, 2014. Most of the treatments included Roundup ProMax (glyphosate) for post-emergence control. Treatments with older, high use rate herbicides included Sahara (diuron + imazapyr), Hyvar (bromacil), Pendulum AquaCap (pendimethalin), and Endurance or ProClipse (prodiamine). Other herbicides used were Oust (sulfometuron), Payload (flumioxazin), Arsenal (imazapyr), Journey (glyphosate + imazapic), and Pyresta (2,4-D + pyraflufen-ethyl). Newer low use rate products tested included Milestone (aminopyralid), Perspective (aminocyclopyrachlor + chlorsulfuron), Viewpoint (aminocyclopyrachlor + metsulfuron + imazapyr), and Esplanade (indaziflam). The proportion (%) of brown vegetation was assessed 20 (5/28/2014) days after treatment (DAT). Visual assessments of % ground cover in these categories: bareground, broadleaves, annual grasses, and perennial grasses were done 96 (8/12/2014) and 196 (10/24/2014) DAT. Treatments with the most bareground at the end of the season (169 DAT) included Hyvar and Esplanade combined with Perspective or Oust. However, these treatments had lower proportions of perennial grasses. The greatest proportion of perennial grasses were in the control and treatments including prodiamine 169 DAT. In many treatments the removal of perennial grasses resulted in more broadleaves and annual grasses.

HERBICIDE RESISTANT WEEDS - EFFORTS AND ENDEAVORS PAST, PRESENT AND FUTURE. Micheal D. Owen*; Iowa State University, Ames, IA (193)

Herbicide resistance has been an increasing problem throughout agriculture since the first report in the early 1970s. Several "waves" of resistance issues have been noteworthy; the first was resistance to the Group 5 herbicides, notably atrazine. This was followed by a more widespread and quickly-evolving resistance to the Group 2 herbicides. These resistances were largely ignored and down-played by the industry and many academics and it was presumed that glyphosate would resolve these issues. Clearly, that was not the case and evolved resistance to glyphosate in a number of important weeds (e.g., *Lolium rigidum*, *Amaranthus palmeri*, *A. tuberculatus* syn. *rudis*, and *Conyza canadensis*) on several continents has seemingly restored weed science to prominence. Weeds have again become recognized as important impediments to efficient and profitable production of food, fuel and fiber. Research papers and presentations at regional, national and international meetings are populated by herbicide resistance topics. The National Academies of Sciences National Research Council commissioned a number of writing committees and study groups with herbicide-resistant weeds as a major focus. There have been numerous symposia, forums, and summits addressing herbicide-resistant weeds. The Congress of the United States House of Representatives Committee on Oversight and Government Reform even convened a special session titled "Are 'Superweeds' an outgrowth of USDA Biotech Policy". Recently, the Secretary of Agriculture Tom Vilsack announced several steps that the United States Department of Agriculture is taking to address an increasing problem with herbicide-resistant weeds in US agricultural systems. He observed that "Weed control in major crops is almost entirely accomplished with herbicides today". A recent report published by the Council for Agricultural Science and Technology (CAST, Issue Paper #55) provides an excellent overview of the benefits of herbicide use but neglected to provide a balanced perspective of the risk of evolved resistance to herbicides. An assessment of alternative weed management tactics is included in the issue paper and fairly addresses some of the concerns with these practices. Herbicides continue to be emphasized as the solution to weed management problems by the industry, academia, and grower and commodity groups and yet the evolution of herbicide-resistant weeds still increases. No herbicides with novel mechanisms of action have been introduced in more than 25 years and many of the programs that are now promoted by the industry are not effective to address existing herbicide resistances and do not follow the Weed Science Society of America published best management practices. A growing number of weed scientists recognize that herbicides alone do not provide robust weed management and are suggesting that alternative practices need to be considered. Given the multiple resistances evolved in the weeds mentioned above, the increasing problems with herbicide resistance in agriculture, and the apparent inability or unwillingness of agriculture to change weed management approaches, different strategies should be considered. These strategies must reflect the socio-economic perspectives of famers and address the changing agricultural demographics. Alternative practices which include, but are not limited to mechanical, cultural and biological tactics, are key to supplement herbicide use. Regulations and incentives may become prominent in weed management. Community-based, bottom up approaches for herbicide-resistant weed management are a possibility that should be investigated.

IOWA FARMERS' PERSPECTIVES ON HERBICIDE RESISTANCE. J G. Arbuckle*; Iowa State University, Ames, IA (194)

The widespread and continuous use of a limited number of postemergence herbicides, especially glyphosate, has led to selection pressure conducive to the evolution of resistances to their modes of action. As a result, herbicide-resistant weeds are becoming increasingly common in Iowa and other Midwestern states, and pose a growing threat to crop yields. The effectiveness of weed management practices depends on maintaining a sufficiently low level of resistance to control techniques. Weed susceptibility to management practices can be considered to be a “common pool resource,” or a resource from which all farmers and society can benefit. When weeds evolve resistance to strategies used to manage them, that common benefit is eroded. Diversification of weed management strategies can be an effective means of herbicide resistance management. This research, which analyzed data from a survey of Iowa farmers, evaluated the influence of various individual, farm, and social network variables on the number of herbicide resistance management (HRM) strategies that farmers use. Results for individual-level variables indicate that older farmers and farmers who believed that “resistance is not a major concern because new technologies will be developed to manage them” reported fewer HRM practices, while farmers who feel that “pest management is a never-ending technology treadmill” and those who develop their own herbicide programs used more diverse practices. Farm-level variables associated with greater HRM diversity include number of crops and livestock produced, gross farm revenue, and recent changes in weed management in response to potential herbicide resistance. A measure of social network influence--trust in Iowa State University for weed management information--was also positively associated with diversity of HRM strategies. Implications of results will be discussed.

KNOCKING DOWN ECONOMIC BARRIERS TO HERBICIDE RESISTANCE MANAGEMENT. Terrance M. Hurley*; University of Minnesota, St. Paul, MN (195)

The emergence of glyphosate resistant weeds in recent years has served as a reminder that herbicide resistance remains a constant challenge to effective weed control. While diverse weed management strategies for tackling this challenge are reasonably well known, these strategies have not been widely adopted. Several important economic barriers help explain why herbicide resistance management (HRM) has not been more widely adopted. The additional cost of HRM in terms of time, material, and complexity are immediate and certain, while the benefits of HRM due to sustained herbicide effectiveness occur in the future and are uncertain. While the average number of cropland acres operated has remained relatively flat over the past thirty years, the distribution of these cropland acres has shifted toward smaller and larger sized farms, and away from medium sized farms. Simple, convenient, and flexible management strategies that free up time make it possible for smaller farms to survive by supplementing on-farm income with off-farm income and larger farms to survive by becoming even larger. The additional costs of HRM are borne by individual farmers, while the benefits extend beyond a farmer’s fields to neighboring farmers’ fields due to the natural and mechanical spread of weed seeds and pollen. The seed supply industry is increasingly coupling insecticidal Bt and herbicide tolerant traits with other important agronomic traits, which helps reduce seed production and distribution costs, but can also reduce the HRM options available to farmers. Effectively knocking down these barriers will require a cooperative, multi-faceted, and adaptive approach. While increasing HRM adoption in the near term can be accomplished using financial and other types of incentives provided through government programs, commodity organizations, farmer cooperatives, or the seed industry, relying exclusively on such an approach is unlikely to be sustainable. Strategies for increasing HRM adoption in the longer term include innovative new resistance management strategies that are less costly in terms of time, material, and complexity; educational programs that help farmers better understand the long term benefits of more diversified weed management; community based programs that coordinate efforts to manage resistance; intellectual property rights reform that broadens the scope of protection for companies that supply herbicides and develop herbicide tolerant traits; and seed market reforms that decouple insect, weed, and disease management seed traits from other important agronomic traits.

HOW MICRO AND MACRO SOCIAL FORCES MAY BE INFLUENCING FARMER RESPONSE TO THE. Raymond A. Jussaume*; Michigan State University, East Lansing, MI (196)

“Wicked Problems” are problems that are considered to be complex in that they involve multiple uncertain causes and effects. Herbicide Resistance Management is one example of a “wicked problem” because the potential causes and effects include biophysical, climatological, technological, economic, social and community factors. In addition, many of these factors involve both micro and macro level factors. Thus, in terms of the social dimension, micro factors may include farmer attitudes toward the environment, household time and financial constraints, and the structure and nature of local farmer social networks that influence farmer decision making. At the macro level, social forces may include government policies, cultural attitudes about farming, and technological change. Clearly, then, understanding the evolution of herbicide resistant weeds, as well as the potential options for addressing this problem, require a holistic interdisciplinary framework that not only understands how the importance of these micro and macro social forces, but also integrates them into a larger framework that examines how these social factors interaction with natural and other human factors.

ADDRESSING SEVERAL BARRIERS TO DIVERSIFICATION OF WEED MANAGEMENT BY REVEALING THE HIDDEN COSTS OF BIOLOGICAL TIME CONSTRAINTS. Jeffrey L. Gunsolus*; University of Minnesota, St. Paul, MN (197)

Emphasis on postemergence weed management tactics came into prominence in corn and soybean cropping systems in the early 1990's with the rapid adoption of the ALS-based sulfonylurea chemistries, nicosulfuron and primisulfuron in corn and the imidazolinone chemistries imazamox and imazethapyr in soybean. In Minnesota, by the mid-1990's nicosulfuron and primisulfuron were used on 33% of Minnesota's corn acres with 73% of the acres treated with a reduced rate of acetochlor or metolachlor. In soybean, imazethapyr or imazamox was used on 70% of Minnesota's approximately 7 million soybean acres and initially these imidazolinone herbicides were used in sequence with soil-applied applications of either trifluralin or pendimethalin. By the mid-1990's total postemergence tactics became more prevalent because it allowed corn and soybean farmers to decouple the time constraints of soil-applied herbicide application from planting date timing. The sequential introduction of Roundup Ready soybean, corn and sugarbeet in 1996, 1998 and 2008, respectively, led to a rapid rate of adoption of total postemergence tactics. By 2011, only 45% of the corn acres were treated with a reduced rate of acetochlor or metolachlor and only 7% of the soybean acres were treated with a soil-applied herbicide. Glyphosate was readily adopted across all three cropping systems and current glyphosate use rates in MN are 90%, 97% and 100% of planted acres for corn, soybean and sugarbeet, respectively. This rapid adoption of the postemergence tactic, in the absence of a diversified weed management strategy, has led to the development of several weed species that are resistant to multiple herbicide mechanisms of action. The end result is a decline in the number of effective mechanisms of action available to each crop, emphasizing that there are only a finite number of herbicide tactics available to farmers. Weed scientists have been stating for years the need for a higher level of weed management that incorporates a greater diversity of weed control tactics. Despite these efforts there has been an increase in the acreage of herbicide-resistant weeds. There is an apparent disconnect that exists between trusted information providers (i.e. crop consultants, chemical/seed industry representatives and extension educators) and farmers. This presentation explores the hypothesis that after 20 years of emphasis on postemergence tactics a generation of farmers has become disconnected from the biological principles that influence and inform the development of durable weed management strategies. This presentation addresses the interface between weed biology and a farmer's time and labor constraints, referred to as biological time constraints. Biological time constraints are time-dependent properties that influence weed management and include: periodicity of weed emergence, rate of weed and crop growth and development, and crop sensitivity to early season weed competition. This presentation will explore the influence that biological time constraints have on profitability and describe educational methodologies that expose these hidden costs to farmers, with the objective of removing some of the barriers to diversification of weed management.

STEWARDSHIP OF BASF CORN HERBICIDES. Walter E. Thomas*, Steven Bowe, Luke Bozeman; BASF Corporation, Research Triangle Park, NC (198)

No abstract submitted

INTRODUCTION OF SYN-A205 FOR ATRAZINE-FREE WEED CONTROL IN CORN. Ryan D. Lins*[1], Scott Cully[2], Thomas H. Beckett[3], Gordon Vail[4], John Foresman[4]; [1]Syngenta, Byron, MN, [2]Syngenta, Marion, IL, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta, Greensboro, NC (199)

SYN-A205 is a new selective herbicide for weed control in field corn, seed corn, popcorn and sweet corn. SYN-A205 contains mesotrione, S-metolachlor, and bicyclopyrone, a new HPPD (4-hydroxyphenyl-pyruvate dioxygenase) inhibitor, with anticipated first commercial applications in the 2016 growing season. In 2014, field trials were conducted to evaluate SYN-A205 for weed control and crop tolerance. Results show that SYN-A205 very effectively controls many difficult weeds and provides improved residual control and consistency compared to other atrazine-free commercial standards.

ACURON: PREEMERGENCE WEED CONTROL AND CORN SAFETY. Thomas H. Beckett*[1], Scott E. Cully[2], Ryan D. Lins[3], Gordon Vail[1]; [1]Syngenta, Greensboro, NC, [2]Syngenta, Marion, IL, [3]Syngenta, Byron, MN (200)

Acuron™ is a multiple mode-of-action herbicide premix that provides preemergence and postemergence grass and broadleaf weed control in field corn (as well as seed corn, sweet corn and yellow popcorn). In addition to mesotrione, s-metolachlor, and atrazine, Acuron™ also contains bicyclopyrone, a new HPPD (4-hydroxyphenyl-pyruvate dioxygenase) inhibitor. Acuron™ applied preemergence is effective on difficult-to-control weeds, including common lambsquarters (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*), giant foxtail (*Setaria faberi*), giant ragweed (*Ambrosia trifida*), Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus rudis*) with improved residual control and consistency compared to commercial standards. Additionally, preemergence applications of Acuron™ are safe to corn. Pending regulatory approvals, first commercial applications are anticipated in the 2015 growing season.

ACURON TOLERANCE IN SWEET CORN. Nicholas E. Hausman*[1], Martin M. Williams II[2]; [1]University of Illinois, Urbana, IL, [2]USDA-ARS, Urbana, IL (201)

Acuron, previously known as SYN-A197, is a new corn herbicide premix containing four active ingredients (*S*-metolachlor, atrazine, mesotrione, and bicyclopyrone) representing three site of action groups. The addition of bicyclopyrone differentiates Acuron from Lumax, which currently is used in sweet corn. Crop metabolism of mesotrione and bicyclopyrone, as well as several other herbicides, is facilitated by cytochrome P450 enzymes. Nonetheless, certain sweet corn inbreds and hybrids can be injured or killed by postemergence applications of several P450-metabolized herbicides. Previous research has shown a single recessive gene in sweet corn conditions cross-sensitivity to multiple P450-metabolized herbicides. To assess potential risk of crop injury from Acuron applied preemergence, sweet corn hybrids were selected from three genotypic classes: hybrids homozygous for mutant P450 alleles (*cypcyp*), hybrids homozygous for functional P450 alleles (*CYPCYP*), and heterozygous hybrids (*CYPcyp*). Herbicide treatments included 1x and 2x standard field use rates of Acuron and Lumax compared to a Bicep II Magnum control. Trials were conducted two years. In 2013, crop injury was not observed. In 2014, crop injury was observed from Acuron and Lumax treatments; however, there was no interaction between genotypic class and herbicide treatment, indicating genotypic class response to Acuron was similar to response to Lumax. Across herbicide treatments, *cypcyp* hybrids displayed 14 and 6% higher crop injury at 7 and 14 days after emergence (DAE), respectively, compared to *CYPCYP* and *CYPcyp* hybrids. Injury was short-lived, as evidenced by minimal crop injury (<3%) 28 DAE and a lack of yield difference among genotypic classes. Acuron appears to pose no greater risk of adverse crop response to sweet corn germplasm than Lumax or Bicep II Magnum, which have been used on the crop for years.

REVULIN™ Q: A NEW POSTEMERGENCE HERBICIDE FOR SEED CORN. Paul Marquardt*[1], Jessica Bugg[2], Kelly Barnett[3], Michael Meyer[4], Jeffery Carpenter[5], Helen A. Flanigan[6]; [1]DuPont Crop Protection, Des Moines, IA, [2]DuPont Crop Protection, Deleware, OH, [3]DuPont Crop Protection, Whiteland, IN, [4]DuPont Crop Protection, Norwalk, IA, [5]DuPont Crop Protection, Johnston, IA, [6]DuPont, Greenwood, IN (202)

Widespread selection of herbicide-resistant weed biotypes in crop production systems demonstrates the importance of a diversified weed management program in order to protect crop yield. Herbicide-resistant weeds are best managed with multiple approaches, including use of multiple-mode of action herbicide premixes. DuPont Crop Protection has developed a unique postemergence herbicide blend, DuPont™ Revulin™ Q herbicide, to control grass and broadleaf weeds in specialty corns, including seed corn inbreds. The premix contains nicosulfuron and dry mesotrione (WSSA Groups 2 and 27, respectively) in addition to a crop safener. The crop safener allows for a wide postemergence application window on both corn hybrids and inbreds, reducing the risk of crop injury. In 2014, crop tolerance and weed efficacy in response to applications of Revulin™ Q was evaluated in ten trials using fourteen seed corn inbreds. In general, crop tolerance to Revulin™ Q was excellent on the inbreds evaluated in these trials. Control of most broadleaf and grass weed species tested was greater than 90%, which was better than or equal to the commercial standard when used in a two-pass weed management program. These data indicate that DuPont Revulin™ Q herbicide provides excellent weed control, is crop-safe across a range of inbreds, and can be used to help manage difficult to control weed species in diverse seed corn production acres.

DUPONT REVULIN Q HERBICIDE, A NEW POSTEMERGENCE HERBICIDE FOR SWEETCORN AND POPCORN. Jeff Krumm*[1], Greg Hannig[2], Keith Diedrick[3], Jessica Bugg[4], Helen Flannigan[5]; [1]DuPont Crop Protection, Hastings, NE, [2]DuPont Crop Protection, Palmyra, NY, [3]DuPont Crop Protection, Rio, WI, [4]DuPont Crop Protection, Richwood, OH, [5]DuPont Crop Protection, Greenwood, IN (203)

The use of herbicide resistant crops has become widespread during the last ten years, in part due to their role in more convenient, more economical weed management programs. The use of herbicide resistant traits is not an option, however, in the specialty corn market; thus conventional herbicides are needed for weed management. DuPont Crop Protection has developed a formulated premix of nicosulfuron + dry mesotrione + isoxadifen-ethyl crop safener for postemergence application to sweetcorn, popcorn, and seed corn that provides selective postemergence control of tough grass and broadleaf weeds. This premix combination, trade name DuPont™ Revulin™ Q herbicide, offers two modes of action, a low use rate, a convenient dry formulation, and excellent crop safety. The addition of the crop safener provides the flexibility for Revulin™ Q to be applied under more diverse weather conditions, and across a wide application window to more seed corn inbreds, and sweet corn and popcorn hybrids by reducing the risk of crop injury. The objective of this study was to evaluate Revulin™ Q in one pass and two pass weed management programs for evaluating weed control and crop response on sweetcorn and popcorn hybrids. The experiment was conducted as a randomized complete block design with 3 to 4 replications, depending on the location, using 11 popcorn hybrids and 17 sweetcorn hybrids at various locations in the United States. Weed control and crop response were evaluated on a scale of 0 = no injury or control and 100% = complete kill at 7 and 14 Days After Treatment (DAT). Difficult to control grass and broadleaf weed species such as large crabgrass, fall panicum, ragweeds, and pigweeds were present in the trial locations. At 7 DAT, Revulin™ Q applied to popcorn showed only 2% injury on average when applied alone and 8% injury when tank mixed with other herbicides. Similar results were observed with sweetcorn at 7 DAT showing only 5% injury when applied alone and up to 8% injury when tank mixed with other herbicides. Injury decreased on both crops to 6% or less for all herbicide combinations at 14 DAT. Overall, Revulin™ Q applied postemergence to popcorn and sweetcorn was found to be safe with a low risk of injury across all hybrids tested. Grass and broadleaf weed control was greater than 90% for many of the weeds evaluated, including: large crabgrass, barnyardgrass, giant foxtail, common lambsquarters, and common ragweed. The addition of DuPont™ Revulin™ Q herbicide to the specialty corn market will provide an effective conventional herbicide option with 2 modes of action with excellent crop safety.

USING INZEN Z SORGHUM TO MANAGE ANNUAL GRASSES POSTEMERGENCE. Curtis R. Thompson*[1], Randall S. Currie[2], Phillip W. Stahlman[3], Alan J. Schlegel[4], Gary Cramer[5], Dallas E. Peterson[1], Jennifer L. Jester[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS, [3]Kansas State University, Hays, KS, [4]Kansas State University, Tribune, KS, [5]Kansas State University, Hutchinson, KS (204)

"Inzen Z" sorghum is the DuPont trade name for sorghum containing a gene transferred from shattercane (SORVU) through traditional breeding. The gene provides resistance to the sulfonylurea grass herbicide nicosulfuron. Experiments were established on Kansas State University Experiment Stations and Research Fields near Manhattan, Hutchinson, Garden City, Tribune, Hays, and Colby, KS to evaluate herbicide programs for Inzen Z sorghum that will manage annual grass and broadleaf weeds. An Inzen Z sorghum hybrid seed, fluxofenim treated, was planted at all locations and S-metolachlor & atrazine (1:1.292) at 2464 g ha^{-1} was applied to the soil surface of four different treatments. All post treatments were applied with nicosulfuron at 35 g ha^{-1}, atrazine at 840 g ha^{-1}, crop oil concentrate at 1% v/v, and spray grade ammonium sulfate at 2240 g ha^{-1}. This tank mix was POST applied alone or with pyrasulfotole & bromoxynil (1:5.65) at 235 g ha^{-1} , dicamba at 280 g ha^{-1}, 2,4-D ester at 280 g ha^{-1} or with 2,4-D ester at 280 g ha^{-1} + metsulfuron at 2.1 g ha^{-1}. The POST applied tank mixes with pyrasulfotole & bromoxynil, dicamba, and 2,4-D ester at rates previously discussed were also used in a two pass system which followed soil applied S-metolachlor & atrazine at rates previous discussed. Injury and weed control were evaluated visually. No sorghum injury was observed from soil applied S-metolachlor & atrazine. When sorghum injury was rated within 7 days of the post applications, nicosulfuron caused sorghum chlorosis and rating ranged from 3 to 20% however chlorosis wasn't evident 2 weeks after application. Growth regulator herbicides caused typical epinasty and tiller sprawling which declined over time to 0% at Colby, Hays, and Garden City. At Manhattan, Tribune, and Hutchinson when growth regulator tank mixes were applied to 12 to 15" sorghum, injury persisted at 4 to 17% 4 weeks after application. POST tank mixes with pyrasulfotole & bromoxynil caused leaf necrosis however, sorghum plants grew out of the injury over time. The treatments containing POST nicosulfuron + atrazine + adjuvants controlled SORVU, conventional grain sorghum, giant foxtail (SETFA), green foxtail, (SETVI), barnyardgrass (ECHCG), witchgrass (PANCA) and volunteer wheat. Annual grasses not adequately controlled with the nicosulfuron + atrazine treatment were large crabgrass (DIGSA) and stinkgrass (ERAME). S-metolachlor & atrazine only provided very good control of all annual grasses except SORVU and volunteer wheat. Two pass programs provided excellent control of all annual grasses evaluated. S-metolachlor & atrazine provided excellent control of tumble pigweed (AMAAL) at Tribune and Hays and excellent Palmer amaranth (AMAPA) control at Manhattan and Hutchinson but inadequate AMAPA control at Garden City and Colby. The two pass systems did provide 100% control of AMAPA at Garden City, Manhattan, and Hutchinson. Post only treatments did not consistently control AMAPA. Nicosulfuron & atrazine alone provided only 65 to 80% control of AMAPA depending on location. The addition of pyrasulfotole & bromoxynil provided 88 to 100% AMAPA control at Manhattan and Garden City but only 73 to 75% control at Colby and Hutchinson. All treatments receiving a post applied herbicide provided better than 90% control of puncturevine (TRBTT). Post treatments which included a growth regulator or pyrasulfotole & bromoxynil controlled velvetleaf (ABUTH) and hybrid sunflower (HELAN) 92 to 100%. Two pass herbicide systems PRE followed by POST will be the most effective way to manage annual grass and broadleaf weeds in Inzen Z sorghum.

EFFECT OF PREVIOUS ATRAZINE USE ON ENHANCED ATRAZINE DEGRADATION IN NORTHERN UNITED STATES SOILS. Thomas C. Mueller*[1], Randall S. Currie[2], Anita Dille[3], William Curran[4], Christy L. Sprague[5], James Martin[6], Kevin W. Bradley[7], Mark L. Bernards[8], Micheal D. Owen[9], Sharon Clay[10], Stevan Z. Knezevic[11], Vince M. Davis[12]; [1]University of Tennessee, Knoxville, TN, [2]Kansas State University, Garden City, KS, [3]Kansas State University, Manhattan, KS, [4]Penn State, University Park, PA, [5]Michigan State University, East Lansing, MI, [6]University of Kentucky, Princeton, KY, [7]University of Missouri, Columbia, MO, [8]Western Illinois University, Macomb, IL, [9]Iowa State University, Ames, IA, [10]South Dakota State University, Brookings, SD, [11]University of Nebraska-Lincoln, Concord, NE, [12]University of Wisconsin-Madison, Madison, WI (205)

Several groups have published on the enhanced degradation of atrazine (ATR) following previous ATR use, including several French researchers, Krutz et al. (several papers), and the Shaner group (several papers). It is clear that the potential exists for ATR to degrade more rapidly in soil than when it was introduced decades ago. This preliminary report examines the behavior of ATR as affected by previous use history in the northern United States where corn is routinely grown. The 10 states that contributed soils to the project were IA, IL, KS, KY, MI, MO, NE, PA, SD, and WI, which gave a wide geographic reach across the U.S. Corn Belt. Soil from each state was collected from the 0 to 10 cm soil depth of "matched" soils: one with > 5 yr of previous ATR use (defined as HISTORY) and one with no known previous ATR use, which was often challenging. Some states willing to contribute could not find verified history soils. Soil samples (~ 800 g) were collected prior to crop planting in spring or early summer of 2014, stored at -15 to 4C, and shipped to TN for the lab assay. Once all samples were received, each soil was placed into a 500 mL styrofoam cup that had five drain holes and water added to saturation. Soils were then allowed to drain for 48 hours, which resulted in a soil at or near field water capacity. This composite sample was divided into sixteen; each with ~5 g of moist soil. Each 5 g sample was placed into a 20 mL glass vial with a screw top lid. Analytical ATR was dissolved in water (stirred with gentle heating) to prepare a fortification solution. This solution was filtered prior to use, and then used in subsequent assays. Each soil sample was fortified to an original concentration of 2200 parts per billion, which approximates a labeled ATR PRE application. Temporal distribution of sampling was -1, 0, 3, 7, 14, 21, 28, and 42 DAT. The -1 DAT sample was analyzed without ATR fortification to determine antecedent ATR levels in each soil. 0 DAT samples were placed into storage at -20C immediately after fortification. Vials containing the soil+ATR were placed into a dark incubator at 22C and placed into cold storage after the appropriate incubation period. Chemical analysis was conducted when all incubations were complete, and all soils were examined in a single, large study. Each soil by incubation time had 2 replicates. ATR concentrations were determined using previously developed methods (Mueller et al 2010) involving extraction with methanol followed by LC-MS to determine parent and metabolites, although only parent ATR is discussed in this report. Recoveries were similar across all soils (> 93%). ATR parent concentration in ppb was regressed using a simple first order regression equation (SigmaPlot 12.5). First order rate constants were then used to calculate half-lives (DT50) for each soil. Enhanced ATR degradation was "defined" as non-history soil DT50/history soil DT 50 > 2.0. Prior to ATR fortification; of 43 soils with non-history only one soil had detectable ATR residue of 11 ppb. Of soils with history, 27 had no detectable ATR and 17 had ATR with an average of 16.9 ppb. The minimum DT50 was 0.7 d, the maximum was 49 d, and the average across all soils was 7.94 d. The average DT50 for non-history soils 13.65 d, whereas the DT50 for history soils was 2.46 d. Of the 48 potential non-history/history comparisons, 42 soils had enhanced degradation with the average enhancement of 7.0. Further research is needed to explain these results. ATR still has utility in the management of glyphosate resistant weeds, although this research implies that the residual control provided by ATR under continuous use is reduced under certain situations.

WEED CONTROL IN DROUGHT TOLERANT AND CONVENTIONAL CORN WITH INCREASING LEVELS OF IRRIGATION WITH AND WITH OUT A WHEAT COVER CROP. Randall S. Currie*, Isaya Kisekka, Sarah Zukoff, Pat Geier, Anthony Zukoff; Kansas State Univ., Garden City, KS (206)

In previous research under limited irrigation, a killed wheat (*Triticum aestivum*) cover crop increased irrigated corn yield despite the opportunity cost of the water used to grow it (Weed Science, 2005, 53: 709-716). Further, this research showed that a cover crop can significantly improve Palmer amaranth (*Amaranthus palmeri*) control with and without atrazine. Drought tolerant corn hybrids are currently being marketed to improve corn yields under limited irrigation. It is not known if the advantage of the cover crop is obviated at some lower level of irrigation or impacted by the use of a drought tolerant corn variety. In the previous mentioned research, only two levels of irrigation were possible. Therefore, it was the objective of this research to measure the impact of a drought tolerant and conventional corn hybrid on yield and weed control under a range of irrigations with and without a cover crop. The experimental design was a randomized complete block with four replications in a split-split plot arrangement. The main plot factor was irrigation level while corn hybrid (drought tolerant and conventional) and cover crop were sub-plot factors. The intent was to apply six irrigation levels (100%=full irrigation, 75%, 50%, 25%, 15%, 6%) within each replication ranging from 2 to 20 inches of water. Within each irrigation treatment a drought tolerant and a conventional near isoline corn hybrid were planted. Within each corn hybrid, the plot was further split into a wheat cover crop portion planted in the fall of 2013 and a no-cover crop portion. A week before corn planting, a glyphosate+ S-metolachlor+mesotrione+atrazine tank mix was applied over the entire plot area at 1.25 + 1.8 + 0.18+ 0.7 lb. ai/a to kill the wheat cover crop and provide the preemergence herbicides for the coming corn crop. Weed control was measured by counting the number plants per plot in 21 to 84 square feet. Glyphosate was applied 48 days after planting (DAP) in the late vegetative stage at 4 lb.ai /a with a high clearance drop nozzle sprayer. Kochia (*Kochia scoparia*) populations have shown a spectrum of resistance to glyphosate near this location. It was reasoned that this high rate of glyphosate would allow inference to uniform glyphosate-resistant population of remaining plants. Rainfall in the summer of 2014 was unusually low from planting to the mid-vegetative stage and well above average for the rest of the season. This did not permit the soil to dry enough to apply the lowest irrigation level. Therefore only 5 levels of irrigation 7, 8, 11, 15 and 17 inches, were applied. There were no significant effects of corn variety on yield or weed control and this factor did not interact with any other factors. Therefore, all data was pooled over corn variety used. In measurement of weed control, cover was the only significant factor and there were no interactions with any other factors. Therefore, cover data was pooled over all other factors. The cover crop prior to termination provided 100% control of Palmer amaranth and green foxtail (*Setaria viridis*) and a 36 and 6 fold reduction in common lambsquarters (*Chenopodium album*) and buffalobur (*Solanum rostratum*). Prior to late post application of glyphosate cover crop treatments provided 100% control of kochia and Johnsongrass (*Sorghum halepense*) and a 2 and 4 fold reduction in green foxtail and puncturevine (*Tribulus terrestris*). At 48 DAP 100% control of Johnsongrass and a 2 fold reduction of puncturevine was provided by the cover crop treatments. Presence or absence of cover (p=0.01) and irrigation level (p=0.01) were statistically significant factors effecting corn yield. However, these factors had a significant interaction (p=0.03). At all levels of irrigation, the cover crop elevated yield. However, there was no pattern in this increase. Cover elevated yield 30, 261, 34, 200 and 8 percent with 7, 8, 11, 15 and 17 inches of irrigation, respectively. These results confirm previous work (Weed Science, 2005, 53: 709-716) and show that the benefits of a killed cover crop to yield and weed control extend over a broad range of moisture conditions.

IMPROVING THE ESTABLISHMENT AND SUBSEQUENT YIELD OF ALFALFA INTERSEEDED INTO SILAGE CORN WITH PROHEXADIONE. Mark J. Renz*[1], John Grabber[2]; [1]University of Wisconsin Madison, Madison, WI, [2]USDA-ARS, Madison, WI (207)

Interseeding alfalfa into silage corn plantings has the potential to provide a cover crop after corn harvest and access to alfalfa harvests in subsequent years. However, previous efforts have resulted in failed alfalfa establishment due to competition from corn. Prohexadione-calcium (PHD) is an inhibitor of gibberellin biosynthesis widely used in ornamental crops for limiting top growth and enhancing root growth and plant tolerance to stress. Such properties could enhance the survival of alfalfa interseeded into silage corn for use as a dual-purpose cover and forage crop. We researched the effectiveness of PHD applied POST directed in replicated field studies at Prairie du Sac Wisconsin from 2008-2014. Fields were planted with imazethapyr- or glyphosate-tolerant corn in early to mid May. Alfalfa was planted between corn rows the following day. Weed management consisted of a broadcast treatment of imazethapyr or glyphosate POST depending on the tolerance of the corn variety to herbicide for weed control. Applications of PHD between 0.7 and 1.0 kg per ha were directed to alfalfa plants when alfalfa was 5 to 20 cm tall. PHD reduced alfalfa top growth by 20% in July of the application year and doubled or tripled alfalfa seedling survival under the corn canopy compared to non-treated controls. Corn silage yield was suppressed by presence of alfalfa by 9-15% compared to the corn only controls regardless of PHD treatment. Yields of alfalfa established the previous year by interseeding were two-fold greater than alfalfa conventionally spring-seeded the spring after corn. Prior year PHD applications increased first year alfalfa yields by 12% and stand densities by up to two-fold compared to untreated interseeded controls. Results suggest PHD can improve alfalfa establishment when interseeded with corn silage and potentially extend alfalfa stand life for several years compared to untreated controls. Ongoing studies are identifying the lowest effective rate and optimal timing of PHD application.

VARRO - A NEW HERBICIDE FOR GRASS CONTROL IN NORTHERN PLAINS CEREALS. Kevin B. Thorsness*[1], Steven R. King[2], Dean W. Maruska[3], Michael C. Smith[4], Charlie P. Hicks[5], George S. Simkins[6], Mark A. Wrucke[7]; [1]Bayer CropScience, Fargo, ND, [2]Bayer CropScience, Research Triangle Park, NC, [3]Bayer CropScience, Warren, MN, [4]Bayer CropScience, Sabin, MN, [5]Bayer CropScience, Fort Collins, CO, [6]Bayer CropScience, St. Paul, MN, [7]Bayer CropScience, Farmington, MN (208)

Varro is a new postemergence grass herbicide that has been developed by Bayer CropScience for use in spring wheat, durum wheat, and winter wheat. Varro is a pre-formulated mixture containing thiencarbazone-methyl and the highly effective herbicide safener, mefenpyr-diethyl. Varro provides consistent control of the most common annual grass species of the northern plains with excellent crop tolerance. Rapid microbial degradation is the primary degradation pathway for thiencarbazone-methyl and mefenpyr-diethyl has no soil activity. Therefore, Varro has an excellent crop rotation profile, allowing re-cropping to the major crops grown in the northern cereal production area including peas and lentils. Varro was successfully launched in the northern plains cereal production area in 2014. Varro is specially formulated as a liquid for easy handling and optimized for grass weed control. Varro at 6.85 fl oz/A can be applied to wheat from emergence up to 60 days prior to harvest in MN, MT, ND, and SD, and 70 days prior to harvest in all other states. Grass weeds should be treated with Varro between the 1-leaf and 2-tiller stage of growth depending on the species. Varro also readily mixes with many broadleaf herbicides for cross-spectrum grass and broadleaf weed control. Varro provides control of ACC-ase resistant and susceptible wild oat and green foxtail, yellow foxtail, and barnyardgrass and partial control of Persian darnel and Japanese brome. Varro also provides control or partial control of 12 broadleaf weed species that are common in the northern cereal production area of the United States. Varro in combination with broadleaf tankmix partners has been shown to increase the control of broadleaf weeds compared to the control provided by the broadleaf herbicides applied alone. Bromus species and foxtail barley were effectively controlled or managed with a tankmix of Varro at 6.85 fl oz/A plus Olympus at 0.2 oz/A in field trials. Varro has been tested on spring wheat, durum wheat, and winter wheat varieties and crop tolerance was excellent. Broad spectrum grass control, excellent crop safety and many recropping options, and the freedom to tankmix with several different broadleaf herbicides makes Varro a valuable and easy to use tool for northern plains cereal grain producers.

DROPLET SIZE EFFECTS ON WILD OAT (*AVENA LUDOVICIANA*) CONTROL IN AUSTRALIAN WHEAT AND CANOLA PRODUCTION. J Connor Ferguson*[1], Chris C. O'Donnell[1], Greg R. Kruger[2], Andrew J. Hewitt[1]; [1]The University of Queensland, Gatton, Australia, [2]University of Nebraska-Lincoln, USA, Lincoln, NE (209)

A study to compare the efficacy of herbicide active ingredients and the effect of droplet size spectra on control of wild oats (*Avena sterilis* L. ssp. *ludoviciana* (Durieu) Nyman) was conducted at the University of Queensland Wind Tunnel Research Facility, in Gatton Queensland, Australia. The study compared three different droplet size spectra: Fine, Coarse and Ultra-Coarse, applied respectively from XR11002, AIXR 11002, and TTI11002 nozzles (Spraying Systems Inc. Wheaton, Illinois, USA) nozzles respectively. Four herbicides were selected to compare efficacy across these three nozzles at two application carrier volumes. The herbicides selected were: pinoxaden at 10 g ai ha^{-1} + cloquintocet-mexyl at 2.5 g ha^{-1} and a methylated seed oil at 500 mL ha^{-1} (Axial® + Adigor®, Syngenta Australia Pty Limited, Macquarie Park, NSW, Australia), imazamox at 11 g ai ha^{-1} + imazapyr at 5 g ai ha^{-1} (Intervix®, BASF Australia Limited, Southbank, VIC, Australia), pyroxsulam at 8 g ai ha^{-1} + cloquintocet-mexyl at 23 g ai ha^{-1} (Crusader®, Dow AgroSciences Australia Limited, Frenches Forest, NSW, Australia), and flamprop-methyl at 113 g ai ha^{-1} (Oat Master®, Farmalinx Pty Limited, Bondi Junction, NSW, Australia). Each tank mix included a 1 g L^{-1}

addition of FD&C Blue #1 for visual assessment of spray coverage. Treatments were applied at 100 L ha^{-1} application carrier volume. Wild oats were sprayed at two different growth stages, 2-3 leaf and tillering. Each treatment included two Kromekote cards for assessment of coverage with each nozzle by herbicide combination. Initial data analysis suggests that the droplet size spectra affects herbicide efficacy.

Author Index

Keyword Index

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