Proceedings of the 70th Annual Meeting of the North Central Weed Science Society

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Midwest Invasive Plant Network Symposium

December 7-10, 2015
Hyatt Regency Indianapolis
Indianapolis, IN

The program and abstracts of posters and papers presented at the annual meeting of the North Central Weed Science Sociey and the Midwest Invasive Plant Network Symposium are included in this proceedings document. Titles are listed in the program by subjet matter with the abstract number listed in parenthesis. Abstracts are listed in numerical order followed by the author and keyword lisitng.

The 2015 NCWSS Proceedings is Dedicated to Dr. Thomas Baumann

Dr. Thomas Trost Bauman, Professor Emeritus, passed away Saturday July 11, 2015 at his home in West Lafayette. Born September 11, 1939 in Lafayette, he was the son of Ronald Hawkins Bauman and Martha G. (Trost) Bauman. He is survived by his loving wife of nearly 50 years, Nancy L. (Sahnd). They were married on August 14, 1965 in Cincinnati, OH. Also surviving are his three children, Bob of Seattle, MaryBeth (Ken) Johnson of West Lafayette, and John (Emily) of West Lafayette; four grandchildren, Olivia and Luke Johnson, and Gretchen and Grant Bauman; his three siblings Ronald "Bill" (Irmgard) Bauman of Los Angeles, CA, Elizabeth "Sis" (Leslie) Graham of Lake Forest, IL and Naples, FL, and Richard (Sharon) Bauman of Punta Gorda, FL; as well as five nieces and seven nephews. Tom attended West Lafayette schools and graduated from WLHS in 1957 where he was active within the student body in numerous roles including student council president and 1956 football MVP. He remained close to his classmates and treasured their friendships, often organizing frequent class reunions and still attending Friday night games. As a lifelong West Lafayette resident, he often served as a West Lafayette and Purdue University amateur historian and tour guide for those visiting from out of town. He attended Purdue University, receiving a B.S., M.S., and PhD in Agriculture. He was a member of Sigma Alpha Epsilon fraternity. Following in his father's footsteps as a professor at his alma mater, he was appointed to the Botany and Plant Pathology Department, with a focus on Extension and Research. Tom and his students were well published in both scientific and Extension journals. He served the North Central Weed Science Society in many capacities culminating with the office of President in 1994 and he was given the Fellow Award, the NCWSS highest honor, in 1996. Tom's work was acknowledged worldwide and he was fortunate to frequently travel internationally to share his work; he particularly enjoyed his extensive efforts in Brazil and remained close friends with many Brazilian scientists. Although Tom was internationally recognized, he was humble and took his greatest joy in helping to train young people, future scientists and simply farming the black Indiana soil, whether it be corn, beans, weeds, or the greatest of hybrid sweet corn. Tom was a caring, kind, concerned person, especially sensitive to his graduate students and those who worked with him in the field. He respected Indiana farmers and enjoyed his many meetings with them, particularly his annual field day at the Purdue Agronomy Farm.

Program

PROGRAM

2015 Officers/Executive Committee

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Executive Secretary-Phil Banks

General Session

Welcome to Indianapolis.*; (93)

How The North Central Weed Control Conference Shaped Agricultural Aviation in the Grasslands. David D. Vail*; Kasnas State Univeristy, Manhattan, KS (94)

NCWSS Presidental Address. John Hinz*; Bayer CropScience, Story City, IA (95)

Necrology Report. Aaron Hager*; Univeristy of Illinois, Urbana, IL (96)

***SPEAKER † STUDENT CONTEST**

Agronomic Crops

Comparisons of winter versus early spring preemergence herbicide applications for kochia control in fallow. Randall S. Currie*1, Patrick Geier2, Curtis R. Thompson3; 1Kansas State Univ., Garden City, KS, 2Kansas State, Garden city, KS, 3Kansas State, Manhattan, KS (97)

†Preharvest Herbicide Application Effects on Winter Wheat Harvestability. Kelsey Rogers*, Christy L. Sprague; Michigan State University, East Lansing, MI (98)

†Evaluation of Herbicide Programs for the Termination of Eight Different Cover Crop Species in the Spring. Cody D. Cornelius*1, Kevin W. Bradley2, Mandy D. Bish3, Alex R. Long2, Meghan E. Biggs2, David L. Kleinsorge4; 1University of Missouri, Columbia MO, MO, 2University of Missouri, Columbia, MO, 3University of Missouri, 65211, MO, 4Research Specialist, Columbia, MO (99)

†Cover Crop Interseeding in Grain Corn using a Modified Grain Drill. Daniel H. Smith*1, Matthew D. Ruark1, Francisco J. Arriaga1, Vince M. Davis2; 1University of Wisconsin-Madison, Madison, WI, 2BASF Corporation, Verona, WI (100)

†Sulfentrazone Tank-mix Partners for Grass Control in Ontario Dry Beans (Phaseolus vulgaris L.). Allison N. Taziar*, Peter H. Sikkema, Darren E. Robinson; University of Guelph, Ridgetown, ON (101)

†Halosulfuron Tank Mixes Applied PPI and PRE in White Bean. Zhenyi Li*1, Rene Van Acker1, Darren E. Robinson2, Nader Soltani2, Peter H. Sikkema2; 1University of Guelph, Guelph, ON, 2University of Guelph, Ridgetown, ON (102)

†Sonic and SureStart II for Palmer Amaranth control in Agronomic Crops. Alinna Umphres-Lopez*1, Tony W. Weiss2, Zachary Lopez3, Thomas C. Mueller1; 1University of Tennessee, Knoxville, TN, 2Dow AgroSciences, Raleigh, NC, 3Dow AgroSciences, Bishop, TX (103)

†Preplant herbicide programs utilizing halauxifen-methyl for management of glyphosate-resistant horseweed (Conyza canadensis L.) in soybean. Marcelo Zimmer*1, Bryan Young2, William G. Johnson1; 1Purdue University, West Lafayette, IN, 2Purdue University, West Layfette, IN (104)

†How to Improve the Consistency of Glyphosate-resistant Canada fleabane (Conyza canadensis L. Cronq.) Control with Saflufenacil: An Investigation of Tank Mix Partners and Optimal Time of Day Application. Christopher M. Budd*1, Peter H. Sikkema1, Darren E. Robinson1, David C. Hooker2, Robert T. Miller3; 1University of Guelph, Ridgetown, ON, 2University of Guelph\, Ridgetown, ON, 3BASF Canada, Mississauga, ON (105)

†Investigations of the Potential Interactions Between Pre-emergence Residual Herbicides and Seed Treatments in Soybean. Blake R. Barlow*1, Alex R. Long1, Meghan E. Biggs1, Mandy D. Bish2, Kevin W. Bradley1; 1University of Missouri, Columbia, MO, 2University of Missouri, 65211, MO (106)

†Soybean yields and critical time for weed removal as influenced by soil applied herbicides. Maxwel C. Oliveira*1, Icaro F. Oliveira e Freitas2, Jon E. Scott2, Stevan Z. Knezevic2; 1University of Nebraska-Lincoln, Lincoln, NE, 2University of Nebraska-Lincoln, Concord, NE (107)

Agronomic Crops I (Corn, Sorghum, Cereals)

Residual control of multiple-resistant Palmer amaranth with soil-applied herbicides in corn. Jonathon R. Kohrt*, Christy L. Sprague; Michigan State University, East Lansing, MI (1)

†Herbicide programs for control of atrazine- and HPPD inhibitors-resistant Palmer amaranth in glufosinate-resistant corn. Parminder S. Chahal*[1], Suat Irmak[1], Todd Gaines[2], Keenan Amundsen[1], Kevin Watteyne[3], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Colorado State University, Fort Collins, CO, [3]Bayer CropScience, Lincoln, NE (2)

Evaluation of new corn herbicides in Northeast Nebraska. Jon E. Scott*[1], Aaron S. Franssen[2], Gail G. Stratman[3], Dennis J. Tonks[4], Kevin Watteyne[5], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE, [3]FMC Corporation, Stromsburg, NE, [4]ISK Biosciences, Kearney, NE, [5]Bayer CropScience, Lincoln, NE (3)

†Evaluation of herbicide programs in ALS resistant sorghum. Eric A. VanLoenen*[1], Anita Dille[1], Curtis R. Thompson[2], Bruce V. Steward[3], Kenneth L. Carlson[4], Philip W. Stahlman[5], Jennifer Jester[5], Alan J. Schlegel[6], Gary Cramer[7]; [1]Kansas State University, Manhattan, KS, [2]Kansas State, Manhattan, KS, [3]DuPont Crop Protection, Overland Park, KS, [4]DuPont Crop Protection, Johnston, IA, [5]Kansas State University, Hays, KS, [6]Kansas State University, Tribune, KS, [7]Kansas State University, Hutchinson, KS (4)

Enlist Weed Control Programs in Enlist Corn. David Ruen*[1], Joe Q. Armstrong[2], Olena O. Castello[3]; [1]Dow AgroSciences, Lanesboro, MN, [2]Dow AgroSciences, Fresno, CA, [3]Dow AgroSciences, Lancaster, PA (5)

†Amaranthus Control and Enhanced Tolerance to Split Preemergence Applications of Pyroxasulfone with Seed-applied Safeners in Grain Sorghum. Loren V. Goodrich*, Patrick Brown, Dean E. Riechers; University of Illinois Urbana-Champaign, Urbana, IL (6)

Control of Field Horsetail (*Equisetum arvense* L.) in Corn. Nader Soltani*[1], Kris McNaughton[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]University of Guelph Ridgetown Campus, Ridgetown, ON (7)

Effect of nozzle selection on herbicide efficacy of four winter grasses. J Connor Ferguson*[1], Rodolfo G. Chechetto[2], Andrew J. Hewitt[3], Bhagirath S. Chauhan[4], Steve W. Adkins[5], Greg R. Kruger[6], Chris C. O'Donnell[1]; [1]University of Queensland, Gatton, Australia, [2]The University of Queensland, São Paulo State University - FCA, Gatton, Australia, [3]The University of Queensland, University of Nebraska-Lincoln, Gatton, Australia, [4]Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Toowoomba, Australia, [5]The University of Queensland, Gatton, Australia, [6]University of Nebraska-Lincoln, North Platte, NE (8)

Introducing DuPont™ Sentrallas™ and DuPont™ Travallas™ New Liquid Sulfonylurea Herbicides for Cereals. Keith A. Diedrick*[1], Keith D. Johnson[2], Jeffrey T. Krumm[3], Bruce V. Steward[4], Robert N. Rupp[5], Kenneth L. Carlson[6]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont Crop Protection, Grand Forks, ND, [3]DuPont Crop Protection, Hastings, NE, [4]DuPont Crop Protection, Overland Park, KS, [5]DuPont Crop Protection, Edmond, OK, [6]DuPont Crop Protection, Johnston, IA (9)

So, What Is Industry Doing To Protect Bees? A Non-traditional Weed Science Topic. James Gifford*, David G. Ouse; Dow AgroSciences, Indianapolis, IN (10)

Does poultry litter influence weed dynamics in corn and soybeans in western Kentucky? Erin Haramoto*[1], Edwin Ritchey[2], Jesse Gray[2]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky Research and Education Center, Princeton, KY (11)

Biologically Effective Dose of Glyphosate as Influenced by Weed Size in Corn. Nader Soltani*[1], Robert E. Nurse[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Agriculture Canada, Harrow, ON (12)

DuPontTM ZestTM herbicide: New Grass Control Option for InzenTM Sorghum. Jeffrey T. Krumm*1, Kenneth L. Carlson2, David W. Saunders2, Robert N. Rupp3, Bruce V. Steward4, Keith D. Johnson5; 1DuPont Crop Protection, Hastings, NE, 2DuPont Crop Protection, Johnston, IA, 3DuPont Crop Protection, Edmond, OK, 4DuPont Crop Protection, Overland Park, KS, 5DuPont Crop Protection, Grand Forks, ND (155)

Weed Management in Inzen Sorghum. Rodrigo Werle*, John L. Lindquist; University of Nebraska- Lincoln, Lincoln, NE (156)

Utilizing Dicamba + Tembotrione for Weed Control in Corn. Mark A. Waddington*1, Mark Wrucke2, Kevin Watteyne3; 1Bayer CropScience, RTP, NC, 2Bayer CropScience, Minneapolis, MN, 3Bayer CropScience, Lincoln, NE (157)

ResicoreTM: A New Corn Herbicide from Dow AgroSciences. Scott Ditmarsen*1, Michael Moechnig2, Mark Peterson3, David Ruen4, David Simpson3, Chris Voglewede3; 1Dow AgroSciences, Madison, WI, 2Dow AgroSciences, Toronto, SD, 3Dow AgroSciences, Indianapolis, IN, 4Dow AgroSciences, Lanesboro, MN (158)

Acuron Flexi: A New Herbicide for Corn. Ryan D. Lins*1, Thomas H. Beckett2, Gordon D. Vail2; 1Syngenta, Rochester, MN, 2Syngenta, Greensboro, NC (159)

Acuron Herbicide: Raising the Bar for Weed Control. Steven P. Mroczkiewicz*1, Scott E. Cully2, Thomas H. Beckett3, Gordon D. Vail3; 1Syngenta, Attica, IN, 2Syngenta, Marion, IL, 3Syngenta, Greensboro, NC (160)

Glyphosate-resistant giant ragweed control in corn and wheat. Peter H. Sikkema*, Nader Soltani; University of Guelph, Ridgetown, ON (161)

Survey of Multiple Herbicide Resistance in Central Kansas Palmer Amaranth. Jennifer Jester*, Philip W. Stahlman; Kansas State University, Hays, KS (162)

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

Volunteer Corn Control in Dicamba – Tolerant Soybeans using Glyphosate + Dicamba + Quizalofop- P ethyl. Larry H. Hageman*[1], Scott E. Swanson[2], Craig M. Alford[3], Keith A. Diedrick[4], Kevin L. Hahn[5], David H. Johnson[3], Keith D. Johnson[6], Jeffrey T. Krumm[7], Michael D. Meyer[3], Charles E. Snipes[8]; [1]DuPont Crop Protection, ROCHELLE, IL, [2]DuPont Crop Protection, Rochelle, IL, [3]DuPont Crop Protection, Johnston, IA, [4]DuPont Crop Protection, Madison, WI, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Grand Forks, ND, [7]DuPont Crop Protection, Hastings, NE, [8]DuPont Crop Protection, Greenville, MS (13)

Control of Enlist corn with clethodim tank-mixed with Enlist Duo. Eric J. Ott*[1], Lowell D. Sandell[2], John A. Pawlak[3]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA Corporation, Lincoln, NE, [3]Valent USA Corporation, Lansing, MI (14)

†Antagonism of clethodim tank-mixed with dicamba or 2,4-D: Response of common garss weeds. Kyle Russell*, Attillio Kandrotas Bercht, Mark L. Bernards; Western Illinois University, Macomb, IL (15)

Weed control, crop tolerance and potential tank contamination in dicamba resistant soybeans. Jon E. Scott*[1], Leo D. Charvat[2], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE (16)

Herbicide Programs for Conventional Till Dicamba-Tolerant Soybeans. Keith A. Diedrick*[1], Kelly A. Backscheider[2], Michael D. Meyer[3], Scott E. Swanson[4], Kevin L. Hahn[5], Keith D. Johnson[6], Jeffrey T. Krumm[7], Donald D. Ganske[8], Victoria A. Kleczewski[9], Robert W. Williams[10], Bruce V. Steward[11], Richard M. Edmund[12], Eric Castner[13], Dan Smith[14], Michael T. Edwards[15], Robert Rupp[16]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont Crop Protection, Shelbyville, IN, [3]DuPont Crop Protection, Johnston, IA, [4]DuPont Crop Protection, Rochelle, IL, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Grand Forks, ND, [7]DuPont Crop Protection, Hastings, NE, [8]DuPont Crop Protection, Winchester, VA, [9]DuPont Crop Protection, Middletown, DE, [10]DuPont Crop Protection, Raleigh, NC, [11]DuPont Crop Protection, Overland Park, KS, [12]DuPont Crop Protection, Little Rock, AR, [13]DuPont Crop Protection, Weatherford, TX, [14]DuPont Crop Protection, Madison, MS, [15]DuPont Crop Protection, Pierre Part, LA, [16]DuPont Crop Protection, Edmond, OK (17)

†Monitoring Factors Associated with the Risk of Off-target Movement of Synthetic Auxin Herbicides in Missouri. Wyatt Coffman*[1], Mandy D. Bish[2], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (18)

†Impact of Tank Cleaning Agents on Ameliorating Dicamba Damage to Soybean (*Glycine max*). Andy J. Luke*[1], Jason W. Weirich[2], Reid J. Smeda[1]; [1]University of Missouri, Columbia, MO, [2]MFA Incorporated, Columbia, MO (19)

Soybean Response to Preplant Applications of Dicamba and Dicamba + 2,4-D Premixes. Nick Fleitz*[1], JD Green[1], James R. Martin[2], Jesse Gray[3]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY, [3]University of Kentucky Research and Education Center, Princeton, KY (20)

Response of Soybean Following the Application of Lactofen, Gibberellic Acid and Foliar Nutrient Combinations. Lowell D. Sandell*[1], Kevin D. Forney[2]; [1]Valent USA Corporation, Lincoln, NE, [2]Valent USA, Bakersfield, CA (21)

***Conyza canadensis* control programs in Enlist soybean.** Kristin Rosenbaum*[1], David Simpson[2], Leah Granke[3], Laura A. Campbell[4], Marcos Baez Buchanan[5]; [1]Dow AgroSciences, Crete, NE, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Columbus, OH, [4]Dow AgroSciences, Carbonale, IL, [5]Dow AgroSciences, Entre Rios, Argentina (22)

Palmer Amaranth Control Options in Enlist Soybean. Michael Moechnig*[1], Kristin Rosenbaum[2], Leah Granke[3], Larry Walton[4], Bobby Haygood[5], Sunil Tewari[6]; [1]Dow AgroSciences, Toronto, SD, [2]Dow AgroSciences, Crete, NE, [3]Dow AgroSciences, Columbus, OH, [4]Dow AgroSciences, Tupelo, MS, [5]Dow AgroSciences, Memphis, TN, [6]Dow AgoSciences, West Lafayette, IN (23)

†Control of *Amaranthus spp.* in Double Crop Soybean. Marshall M. Hay*, Dallas E. Peterson, Doug E. Shoup; Kansas State University, Manhattan, KS (24)

Evaluation of new herbicide tolerant crops: Bolt Beans and Balance Beans. Stevan Z. Knezevic*[1], Jeffrey T. Krumm[2], Kevin Watteyne[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]DuPont Crop Protection, Hastings, NE, [3]Bayer CropScience, Lincoln, NE (25)

BOLT™ Technology Soybeans for Improved Plant-Back Flexibility after DuPont™ Finesse® Herbicide Application to Wheat. Kelly A. Backscheider*[1], Larry H. Hageman[2], Jeffrey T. Krumm[3], Scott E. Swanson[4], Bruce V. Steward[5], Michael T. Edwards[6], Robert N. Rupp[7], Robert W. Williams[8], Richard M. Edmund[9], Victoria A. Kleczewski[10], David H. Johnson[11]; [1]DuPont Crop Protection, Shelbyville, IN, [2]DuPont Crop Protection, ROCHELLE, IL, [3]DuPont Crop Protection, Hastings, NE, [4]DuPont Crop Protection, Rochelle, IL, [5]DuPont Crop Protection, Overland Park, KS, [6]DuPont Crop Protection, Pierre Part, LA, [7]DuPont Crop Protection, Edmond, OK, [8]DuPont Crop Protection, Raleigh, NC, [9]DuPont Crop Protection, Little Rock, AR, [10]DuPont Crop Protection, Middletown, DE, [11]DuPont Crop Protection, Johnston, IA (26)

Glufosinate (LibertyLink) and Glyphosate (Roundup Ready/GT) Weed Control Programs for SOA 2- and SOA 9-Resistant Giant Ragweed in Soybean. Lisa M. Behnken*[1], Fritz R. Breitenbach[2], Jeffrey L. Gunsolus[3]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota Extension, St. Paul, MN (27)

†Control of Glyphosate-Resistant Common Ragweed (*Ambrosia artemisiifolia* L) in Glufosinate-Resistant Soybean. Ethann R. Barnes*[1], Peter H. Sikkema[2], Stevan Z. Knezevic[3], John L. Lindquist[1], Amitkumar J. Jhala[4]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Guelph, Ridgetown, ON, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska-Lincoln, Lincoln, NE (28)

†S.T.O.P Weeds with Glufosinate - Best Management Practices. Aaron M. Helbling*[1], Kevin B. Thorsness[1], Angela J. Kazmierczak[1], John B. Christianson[1], Bill Shores[2], Arlene Cotie[3]; [1]Bayer CropScience, Fargo, ND, [2]Bayer CropScience, Fergus Fall, MN, [3]Bayer Crop Science, Raleigh, NC (29)

Use of weed screens to evaluate PRE and POST herbicide concepts in soybean. Stevan Z. Knezevic*[1], David A. Feist[2], Steve Eskelsen[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]ADAMA, Fort Collins, CO, [3]ADAMA, Kennewick, WA (30)

Introduction of Surveil® herbicide for preplant and preemergence weed control in soybean. Joe Armstrong[1], Jeffrey Ellis*[2], Chris Voglewede[3], Mark Peterson[3]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Sterlington, LA, [3]Dow AgroSciences, Indianapolis, IN (31)

Managing Waterhemp in Soybeans with Layered Residual Herbicides. A Strategy for Controlling Glyphosate Resistant Waterhemp in Minnesota. Lisa M. Behnken*[1], Fritz R. Breitenbach[2], Jeffrey L. Gunsolus[3]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota Extension, St. Paul, MN (32)

†Season-Long Control of Glyphosate-Resistant Common Waterhemp as Influenced by Split-Applications of Very Long Chain Fatty Acid Synthesis Inhibitors in Soybean. Debalin Sarangi*[1], Lowell D. Sandell[2], Stevan Z. Knezevic[3], John L. Lindquist[4], Suat Irmak[1], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Valent USA Corporation, Lincoln, NE, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska- Lincoln, Lincoln, NE (33)

†Has Soybean Breeding Over 80 Years Selected for Increased Competitiveness with Weeds? Devin Hammer*, Shawn Conley; University of Wisconsin-Madison, Madison, WI (34)

†Soybean yield as affected by planting date and relative removal time of cover crop or winter annual weeds. Kristina Simmons*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (35)

†Weed Management Techniques for Organic Soybeans (*Glycine max*). Ricardo C. Silva*, Carey F. Page, Reid J. Smeda; University of Missouri, Columbia, MO (36)

Herbicide Programs for Kochia Control in Dicamba-Tolerant Soybeans. Jeffrey T. Krumm*1, David H. Johnson2, Keith D. Johnson3, Bruce V. Steward4, Robert N. Rupp5; 1DuPont Crop Protection, Hastings, NE, 2DuPont Crop Protection, Johnston, IA, 3DuPont Crop Protection, Grand Forks, ND, 4DuPont Crop Protection, Overland Park, KS, 5DuPont Crop Protection, Edmond, OK (179)

Herbicide Programs for Marestail Control in Dicamba-Tolerant Soybeans. Jessica R. Bugg*1, Jeffrey T. Krumm2, Keith A. Diedrick3, Kelly A. Backscheider4, Kevin L. Hahn5, David H. Johnson6; 1DuPont Crop Protection, Marysville, OH, 2DuPont Crop Protection, Hastings, NE, 3DuPont Crop Protection, Madison, WI, 4DuPont Crop Protection, Shelbyville, IN, 5DuPont Crop Protection, Bloomington, IL, 6DuPont Crop Protection, Johnston, IA (180)

Engenia Herbicide: Optimizing Performance and Product Stewardship in Dicamba Tolerant Crops. John Frihauf*1, Chad Brommer2, Joseph Zawierucha2, Steven Bowe3; 1BASF, Lincoln, NE, 2BASF, Research Triangle Park, NC, 3BASF, RTP, NC (181)

Multi-crop Bioassay of Simulated Dicamba Residue in Soil. Theresa A. Reinhardt*, Rich Zollinger; North Dakota State University, Fargo, ND (182)

Interaction Between XtendimaxTM and Group 1 Herbicides for Volunteer Corn Control in Soybean. Matthew G. Underwood*1, Peter Sikkema1, David C. Hooker2, Darren E. Robinson1, Joseph P. Vink3; 1University of Guelph, Ridgetown, ON, 2University of Guelph\, Ridgetown, ON, 3Monsanto Canada, Winnepeg, MB (183)

Efficacy of Sequential Herbicide Programs Containing Fomesafen and Seedling Shoot Inhibitors in Soybeans. Timothy L. Trower*1, Brett Miller2, Donald J. Porter3, Thomas H. Beckett3; 1Syngenta, Baraboo, WI, 2Syngenta, Minnetonka, MN, 3Syngenta, Greensboro, NC (184)

Refreshing residuals: value of metribuzin + flumioxazin for weed control in soybeans. Dawn Refsell*1, Lowell D. Sandell2, Eric J. Ott3, Trevor M. Dale4, Ron Estes5, John A. Pawlak6; 1Valent USA Corporation, Lathrop, MO, 2Valent USA Corporation, Lincoln, NE, 3Valent USA Corporation, Greenfield, IN, 4Valent USA Corporation, Minneapolis, MN, 5Valent USA Corporation, Champaign, IL, 6Valent USA Corporation, Lansing, MI (185)

Warrant Ultra: A New Residual and Postemergence Herbicide Option in Soybean. Justin Pollard*1, John Willis2, Ryan Rapp3; 1Monsanto, Lathrop, MO, 2Monsanto, Creve Coeur, MO, 3Monsanto, Mitchell, SD (186)

New Zero-Day Plant-Back Options for DuPont™ Basis® Blend and LeadOff® Herbicides in BOLT™ Technology Soybean . Paul Marquardt*1, Kevin L. Hahn2, Michael D. Meyer3, Larry H. Hageman4, Kelly A. Backscheider5, Keith A. Diedrick6, Keith D. Johnson7, Scott E. Swanson8, Jeffrey T. Krumm9, Richard M. Edmund10, David H. Johnson3; 1DuPont Crop Protection, Des Moines, IA, 2DuPont Crop Protection, Bloomington, IL, 3DuPont Crop Protection, Johnston, IA, 4DuPont Crop Protection, ROCHELLE, IL, 5DuPont Crop Protection, Shelbyville, IN, 6DuPont Crop Protection, Madison, WI, 7DuPont Crop Protection, Grand Forks, ND, 8DuPont Crop Protection, Rochelle, IL, 9DuPont Crop Protection, Hastings, NE, 10DuPont Crop Protection, Little Rock, AR (187)

Utility of ArylexTM Active Herbicide for Pre-Plant Burndown Applications. Jeff M. Ellis*1, Chris Voglewede2, Joe Armstrong3, Leah Granke4, Laura A. Campbell5, Kristin Rosenbaum6, Mark A. Peterson7, David Simpson2; 1Dow AgroSciences, Sterlington, LA, 2Dow AgroSciences, Indianapolis, IN, 3Dow AgroSciences, Davenport, IA, 4Dow AgroSciences, Columbus, OH, 5Dow AgroSciences, Carbonale, IL, 6Dow AgroSciences, Crete, NE, 7Dow AgroSciences, West Lafayette, IN (188)

Introducing BOLT™ Technology: A New Herbicide System for Cleaner Fields and Greater Management Flexibility in Soybeans. David Johnson*1, Helen A. Flanigan2, Jeff Carpenter1, Steven Strachan3, Steven Mitchell4, Andre Trepanier4, Mark Vogt4, Scott Sebastian4; 1DuPont Crop Protection, Johnston, IA, 2DuPont, Greenwood, IN, 3DuPont Crop Protection, Newark, DE, 4DuPont Pioneer, Johnston, IA (189)

Equipment and Application Methods

Methods for Assessing Rainfastness of Herbicide / Safener Combinations. David G. Ouse*[1], Roger Gast[1], James Gifford[1], Andrea McVeigh[1], Debbie Bingham-Burr[2]; [1]Dow AgroSciences, Indianapolis, IN, [2]Kelly Scientific, Indianapolis, IN (37)

†Establishing Drift Reduction Ratings for Ground Nozzles and Tank-mixtures Using the EPA's Guidelines. Ryan S. Henry*[1], William E. Bagley[2], Jerome J. Schleier III[3], Patrick L. Havens[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]Dow AgroSciences, Indianapolis, IN (38)

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Abstracts

RESIDUAL CONTROL OF MULTIPLE-RESISTANT PALMER AMARANTH WITH SOIL-APPLIED HERBICIDES IN CORN. Jonathon R. Kohrt*, Christy L. Sprague; Michigan State University, East Lansing, MI (1)

Field experiments were conducted in 2013, 2014, and 2015 near Middleville, MI to evaluate the effectiveness of soil-applied herbicides on the control of multiple-resistant Palmer amaranth. This population has demonstrated resistance to glyphosate (group 9), ALS-inhibitors (group 2), and has shown variable tolerance to atrazine (group 5). Saflufenacil, mesotrione, isoxaflutole, acetochlor, *s*-metolachlor, and pyroxasulfone were applied alone and in combination with atrazine at 1.12 kg ai ha^{-1} prior to crop and weed emergence. Additional treatments included: atrazine alone at 1.12 and 2.24 kg ai ha^{-1}, saflufenacil + pyroxasulfone, and several commercially available premixtures. Palmer amaranth control was evaluated throughout the growing season and biomass was harvested 45 days after treatment (DAT). Pyroxasulfone applied alone was the only herbicide that provided greater than 80% control of Palmer amaranth 45 DAT for all three years. Palmer amaranth control was less than 50% in 2 of 3 years with atrazine and isoxaflutole. The addition of atrazine did not improve Palmer amaranth control with any of the treatments, except when it was applied in combination with mesotrione. All of the commercially available premixtures evaluated provided greater than 80% control in 2 of 3 years 45 DAT. Over the three years there was substantial variability in the level of Palmer amaranth control in this population. The increased levels of control in 2015 could possibly indicate that there may be a fitness penalty associated with the level of triazine resistance in this population. While some of the herbicide programs evaluated provided adequate levels of Palmer amaranth control well into the growing season, a follow up postemergence application with an effective herbicide would have been necessary for complete control of this multiple-resistant Palmer amaranth population.

HERBICIDE PROGRAMS FOR CONTROL OF ATRAZINE- AND HPPD INHIBITORS-RESISTANT PALMER AMARANTH IN GLUFOSINATE-RESISTANT CORN. Parminder S. Chahal*[1], Suat Irmak[1], Todd Gaines[2], Keenan Amundsen[1], Kevin Watteyne[3], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Colorado State University, Fort Collins, CO, [3]Bayer CropScience, Lincoln, NE (2)

Palmer amaranth, also known as careless weed, is one of the most troublesome weeds in the agronomic crop production systems of the United States. Field experiment was conducted in 2015 in a field infested with atrazine and HPPD-inhibitor-resistant Palmer amaranth near Shickley, Nebraska. The study was laid out in a randomized completed block design with eighteen herbicide treatments and four replications in glufosinate-resistant corn. Herbicide treatments included different PRE followed by POST, PRE or POST only herbicides applications. At 21 d after PRE application, Palmer amaranth was controlled > 85% with all the PRE herbicide used in this study. At 28 d after POST or 49 d after PRE application, all the PRE *fb* POST and POST only herbicide controlled Palmer amaranth > 95% compared to < 80% control with PRE only herbicide treatments. No crop injury was observed with the PRE and POST herbicides applications. The percent shoot biomass reduction and visual control estimates of Palmer amaranth were usually similar at 28 d after POST herbicides applications. Most of the treatments provided higher yields (> 14550 kg/ha) compared with nontreated control.

EVALUATION OF NEW CORN HERBICIDES IN NORTHEAST NEBRASKA. Jon E. Scott*[1], Aaron S. Franssen[2], Gail G. Stratman[3], Dennis J. Tonks[4], Kevin Watteyne[5], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Syngenta Crop Protection, Seward, NE, [3]FMC Corporation, Stromsburg, NE, [4]ISK Biosciences, Kearney, NE, [5]Bayer CropScience, Lincoln, NE (3)

As weed resistance to herbicides increases, new herbicides or herbicide combinations are needed to combat this growing problem. Therefore, several new products were tested in Northeast Nebraska during 2015 season to determine weed efficacy, especially on common waterhemp. Atrazine + bicyclopryone +mesotrione + S-metolachlor (Acuron™) applied PRE provided excellent season long control (98-100%) of lambsquarters, velvetleaf and waterhemp compared to good to excellent control (96-100%) of the same weeds with just atrazine + mesotrione +S- metolachlor (Lumax ® EZ). Both products provided 75% to 80% of green foxtail at 64 DAT. Isoxaflutole + thiencarbazone without any added atrazine provided 91% control of green foxtail, 100% of lambsquarter and velvetleaf, and 58% control of waterhemp. No corn injury was observed. Mesotrione + fluthiacet-methyl tankmixed with glyphosate provided excellent broadleaf control and fair (80%) foxtail control, but addition of atrazine helped foxtail control. To extend residual and add sites of action; pyroxasulfone + fluthiacet-methyl was added to mesotrione + fluthiacet-methyl tankmixed with glyphosate; with and without atrazine. These combinations provided complete control. Corn exhibited excellent tolerance to tolpyralate. Control of green foxtail and waterhemp ranged from 70-80%, compared to lambsquarter and velvetleaf at 90-99% when applied at 5-10 cm with a surfactant at rates of 29-39 g ai/ha. Addition of atrazine or atrazine + metolachlor and especially glyphosate to tolpryalate provided season long weed control. Similar results were observed when isoxaflutole + thiencarbazone was followed by tembotrione + thiencarbazone + dicamba + safener. While none of these new herbicides contained a new mode of action, combining current chemistries with different sites of action is one method to manage herbicide resistant weeds. Timing PRE application before rainfall can help obtain good activation of soil applied treatments and selection of products that have residual activity in POST treatments can also help.

EVALUATION OF HERBICIDE PROGRAMS IN ALS RESISTANT SORGHUM. Eric A. VanLoenen*[1], Anita Dille[1], Curtis R. Thompson[2], Bruce V. Steward[3], Kenneth L. Carlson[4], Philip W. Stahlman[5], Jennifer Jester[5], Alan J. Schlegel[6], Gary Cramer[7]; [1]Kansas State University, Manhattan, KS, [2]Kansas State, Manhattan, KS, [3]DuPont Crop Protection, Overland Park, KS, [4]DuPont Crop Protection, Johnston, IA, [5]Kansas State University, Hays, KS, [6]Kansas State University, Tribune, KS, [7]Kansas State University, Hutchinson, KS (4)

DuPont Crop Protection is introducing new sorghum technology branded Inzen™ sorghum. The new technology provides a resistant gene in Inzen™ sorghum, which allows for applications of sulfonylurea grass herbicides rimsulfuron applied preemergence and nicosulfuron applied postemergence. Experiments were set up at four Kansas State University research stations across the state near Tribune, Hays, Hutchinson, and Manhattan, KS. The main objectives of these experiments were to evaluate herbicide programs for grass and broadleaf weed control and sorghum tolerance. Experiments were a randomized complete block design with four replications and consisted of ten herbicide programs and one untreated check. This design was consistent with all locations expect for Hays, KS. The Hays experiment was a randomized complete block design with six herbicide programs and four replications. In all experiments a single Inzen™ grain sorghum hybrid was used. The experiments at Hutchinson, Tribune, and Manhattan consisted of early pre-plant, preemergence, and postemergence herbicide applications. The early pre-plant herbicide was rimsulfuron + thifensulfuron (1:1) and applied at 63 g/ha 2 weeks before planting. At planting all experiments received a broadcast burndown application of glyphosate at 1140 g ae/ha and ammonium sulfate at 2% w/v. Six treatments received a preemergence application of atrazine + S-metolachlor (1.2916:1) applied at 2464 g/ha. Two of the six treatments also had rimsulfuron + thifensulfuron at 63 g/ha. Eight treatments received postemergence herbicides. All post treatments were applied with nicosulfuron at 35 g/ha, atrazine at 841 g/ha, crop oil concentrate at 1% v/v and ammonium sulfate at 2243 g/ha. The early preplant and four preemergence treatments were followed by a post application of nicosulfuron at 35 g/ha. Two post treatments also included pyrasulfotole + bromoxynil (1:5.65) at 235 g/ha. Two different postemergence treatments received dicamba at 280g ae/ha. The Hays experiment consisted of an early pre-plant rimsulfuron + thifensulfuron at 63 g/ha followed by postemergence applied nicosulfuron at 35 g/ha, preemergence applied atrazine + S-metolachor at 2464 g/ha, preemergence applied tank mix of atrazine + S-metolachor at 2464 g/ha and rimsulfuron + thifensulfuron at 35 g/ha and a preemergence applied atrazine + S-metolachor at 2464 g/ha with or without rimsulfuron + thifensulfuron at 35 g/ha followed by post applied nicosulfuron at 35 g/ha and atrazine at 840 g/ha. Weed control and crop response were evaluated visually at 7, 14, and 28 days after application (DAA). Sorghum biomass was taken at boot stage at each location except Hays. No visual injury was observed with any soil applied herbicides regardless of location. Treatments containing nicosulfuron and/or pyrasulfotole + bromoxynil caused 10-20% chlorosis when rated 7 DAA, however little to no injury was observed at 14 DAA. Some leaf necrosis was observed with treatments containing pyrasulfotole + bromoxynil, however, sorghum had completely recovered by 28 DAA. Treatments containing dicamba injured sorghum from 15-30% 7 DAA. Sorghum recovered from dicamba injury by 28 DAA. Dicamba treatments did reduce sorghum biomass at Manhattan, KS. Conventional sorghum (SORVU) planted across each plot was not controlled with any soil applied herbicides, however all POST treatments containing nicosulfuron controlled SORVU 100%. Atrazine + S-metolachlor when activated controlled Palmer amaranth (AMAPA), carpetweed (MOLVE), and annual grasses yellow foxtail (SETPU), large crabgrass (DIGSA), and stinkgrass (ERAME). All post herbicide treatments controlled MOLVE. Nicosulfuron + atrazine only controlled AMAPA 64% and when tank mixed with dicamba or pyrasulfotole + bromoxynil, control ranged from 71 to 76%. When nicosulfuron + atrazine followed preemergence atrazine + S-metolachor AMAPA was controlled 96 to 100%. Nicosulfuron + atrazine only provided 25 to 61% control of SETPU, SETVI, DIGSA, and ERAME . When nicosulfuron + atrazine combinations followed atrazine + S-metolachlor, control of the annual grasses ranged from 85 to 100%. Herbicide programs for Inzen™ sorghum can provide adequate grass control, however an essential component of the total program includes the use of a preemergence application of atrazine plus a chloroacetamide herbicide followed by the post application of nicosulfuron, which should be tank mixed with a herbicide that provides effective control of broadleaf weeds.

ENLIST WEED CONTROL PROGRAMS IN ENLIST CORN. David Ruen*[1], Joe Q. Armstrong[2], Olena O. Castello[3]; [1]Dow AgroSciences, Lanesboro, MN, [2]Dow AgroSciences,

Fresno, CA, [3]Dow AgroSciences, Lancaster, PA (5) Enlist ™ Corn Weed Control Programs in Midwest. David C. Ruen, Joe Q. Armstrong, and Olena Castello.

The Enlist™ Weed Control System is being developed in multiple crops including Enlist™ corn. Enlist corn has been extensively evaluated in field research trials since 2006 and was deregulated by the United States Department of Agriculture in September 2014. Enlist corn, stacked with SmartStax® trait technology, provides tolerance to both 2,4-D and glyphosate as well as above- and below-ground insect resistance. Enlist Duo™ herbicide with Colex-D™ Technology is a proprietary blend of 2,4-D choline and glyphosate dimethylamine (DMA) developed by Dow AgroSciences for use on Enlist crops. Enlist Duo was registered with the U.S. Environmental Protection Agency in October 2014. Dow AgroSciences will be recommending the use of soil residual herbicides as a part of the Enlist system to provide early season weed control and crop yield protection along with additional modes of action to manage weed resistance. Field research trials were conducted in 2013 (19 trials), 2014 (23 trials) and 2015 (12 trials) to evaluate herbicide programs including Enlist Duo (2,4-D choline + glyphosate DMA) and SureStart II™ herbicide (acetochlor + clopyralid + flumetsulam) for weed control and crop tolerance. Treatments included SureStart applied preemergence (PRE) followed by a postemergence (POST) application of Enlist Duo to V4 corn, Enlist Duo + SureStart applied early postemergence (EPOST) to V2 corn, Enlist Duo + SureStart applied POST to V4 corn, and Enlist Duo, by itself, EPOST and POST. SureStart PRE rate varied by soil type (1170 to 1750 g ae/ha) and SureStart EPOST and POST rate by protocol (875 to 1170 g ae/ha). Enlist Duo was applied POST (1640 and 2185 g ae/ha) following PRE applications of SureStart, as a tank-mix with SureStart applied EPOST and POST, or applied by itself, EPOST and POST. At 28 days after the POST application timing, SureStart PRE followed by Enlist Duo POST provided greater than 95% control of glyphosate-resistant waterhemp, common ragweed, and giant ragweed and 98% or greater control of glyphosate-susceptible weed species. Enlist Duo + SureStart POST provided 97% or greater control of glyphosate- resistant waterhemp and common ragweed and 87 to 93% giant ragweed. POST Enlist Duo + SureStart treatments provided 94% or greater control of glyphosate-susceptible weed species. Corn tolerance was evaluated 7 and 14 days after the POST applications. SureStart applied PRE followed by Enlist Duo POST averaged less than 2% visual injury 14 days after application. The tank-mix of Enlist Duo + SureStart POST resulted in 2% or less visual injury 14 days after application. Residual herbicides are an effective tool to prevent yield loss caused by early season weed competition and bring additional modes of action to the weed control program as a component of weed resistance management best practices. These trials demonstrate the utility of residual PRE herbicides followed by POST applications of Enlist Duo as part of the Enlist system in Enlist corn.™® Enlist, Enlist Duo and SureStart, 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. SmartStax® multi-event technology developed by Monsanto and Dow AgroSciences, LLC. SmartStax® and the SmartStax logo are registered trademarks of Monsanto Technology, LLC.

AMARANTHUS CONTROL AND ENHANCED TOLERANCE TO SPLIT PREEMERGENCE APPLICATIONS OF PYROXASULFONE WITH SEED-APPLIED SAFENERS IN GRAIN SORGHUM. Loren V. Goodrich*, Patrick Brown, Dean E. Riechers; University of Illinois Urbana-Champaign, Urbana, IL (6)

Controlling weeds selectively is one of the most significant challenges facing grain sorghum farmers. Gene flow from crop to wild and weedy relatives occurs almost everywhere grain sorghum is cultivated, therefore eliminating the use of transgenes in grain sorghum for crop protection. Due to this potential for gene flow to weedy relatives, alternative solutions must be explored in order to selectively control weeds in sorghum. A field study was conducted in 2015 in Urbana, Illinois to evaluate the protective ability of the seed-applied safener fluxofenim (Concep III) from the preemergence (PRE) herbicide pyroxasulfone (Zidua) at single and split application times in hybrid grain sorghum, which was planted on June 7. The randomized complete block plot design was split by seed treatment (plus or minus fluxofenim safener). Herbicide treatments consisted of a total of six rates of pyroxasulfone, either applied PRE at 90, 120, 180, or 210, or split PRE/early postemergence applications at 90/120, or 120/90 g ai ha^{-1}. A PRE treatment of *s*-metolachlor at 1.43 kg ai ha^{-1} plus an untreated-weedy control and a weed-free control plots were included for comparison with pyroxasulfone. The weed-free control was maintained by hand hoeing in the unsafened plots, or consisted of a PRE application of *s*-metolachlor and atrazine in conjunction with hand weeding in the safened plots. The study was conducted on a field site with a natural population of waterhemp (*Amaranthus tuberculatus*). Weed control and crop injury were assessed to compare the effects of pyroxasulfone to *s*-metolachlor applied PRE in grain sorghum. Visual weed control ratings were taken 21, 28 and 42 d after treatment. Results indicate that weed control was significantly greater with the two highest rates and split applications of pyroxasulfone than with *s*-metolachlor. However, as weed control increased with the two highest pyroxasulfone treatments, crop injury also increased regardless of safener. Final yield and yield parameters, including grain per plant and grain per plot, will be analyzed and compared among PRE treatments to further evaluate the efficacy of fluxofenim in protecting grain sorghum from pyroxasulfone.

CONTROL OF FIELD HORSETAIL (*EQUISETUM ARVENSE* L.) IN CORN. Nader Soltani*[1], Kris McNaughton[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]University of Guelph Ridgetown Campus, Ridgetown, ON (7)

Six field trials were conducted during 2013 and 2014 on various Ontario farms with heavy field horsetail infestations to determine the effectiveness of various postemergence (POST) herbicides for the control of field horsetail in corn. There was minimal and transient corn injury (3% or less) with nicosulfuron/rimsulfuron, flumetsulam or nicosulfuron/rimsulfuron + flumetsulam. In contrast, MCPA amine, nicosulfuron/rimsulfuron + MCPA amine, flumetsulam + MCPA amine, and nicosulfuron/rimsulfuron + flumetsulam + MCPA amine caused as much as 6% injury in corn. Nicosulfuron/rimsulfuron, flumetsulam, MCPA amine, nicosulfuron/rimsulfuron + flumetsulam and nicosulfuron/rimsulfuron + MCPA amine applied POST controlled field horsetail 22-68% and reduced density 27-64% and biomass 38-77%. Flumetsulam + MCPA amine and nicosulfuron/rimsulfuron + flumetsulam + MCPA amine controlled field horsetail 69-83% and reduced density and biomass as much as 87%. Based on these results, flumetsulam + MCPA amine and nicosulfuron/rimsulfuron + flumetsulam + MCPA amine provide the best and most consistent control of field horsetail in corn among POST herbicides evaluated.

EFFECT OF NOZZLE SELECTION ON HERBICIDE EFFICACY OF FOUR WINTER GRASSES. J Connor Ferguson*[1], Rodolfo G. Chechetto[2], Andrew J. Hewitt[3], Bhagirath S. Chauhan[4], Steve W. Adkins[5], Greg R. Kruger[6], Chris C. O'Donnell[1]; [1]University of Queensland, Gatton, Australia, [2]The University of Queensland, São Paulo State University - FCA, Gatton, Australia, [3]The University of Queensland, University of Nebraska-Lincoln, Gatton, Australia, [4]Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Toowoomba, Australia, [5]The University of Queensland, Gatton, Australia, [6]University of Nebraska-Lincoln, North Platte, NE (8)

A study to compare the effect of spray quality on the herbicide efficacy for control of four winter grasses was conducted at the University of Queensland in Gatton, Queensland (QLD), Australia. The study compared across different droplet size spectra, and nozzles are listed in Table 1. The herbicides selected were: clodinafop-propargyl + a methylated seed oil at 50.4 g ai ha^{-1} + 0.5 % v/v; imazamox and imazapyr + exthoxylated vegetable oil at 25 g ai ha^{-1} and 11.4 g ai ha^{-1} 0.5 % v/v; metribuzin, at 330 g ai ha^{-1}; glyphosate at 570 g ai ha^{-1}; paraquat at 300 g ai ha^{-1}; and amitrole + soyal surfactant at 1,400 g ai ha^{-1} + 0.1 % v/v . Rates were selected based on recommended control for grasses at the four leaf to tillering growth stage in Queensland. The winter grasses selected for the study were: oats, (*Avena sativa* L.) var. 'Yarran'; prairie grass (*Bromus willdenowii* Kunth) var. 'Atom'; annual ryegrass (*Lolium rigidum* Gaudin) var. 'Mach 1' ; and Italian ryegrass (*L. multiflorum* Lam.) var. 'Knight'; all above varieties were supplied by AusWest Seeds, Forbes, NSW, Australia. Plants were grown outside and irrigated twice daily. Plants were sprayed at the tillering growth stage on 11 August and the study replicated and sprayed on 6 October, 2015. Treatments were applied at 10.4 km hr^{-1} to achieve the 100 L ha^{-1} application volume. Nozzles were operated at 350 kPa, which produce a Fine, Medium, Coarse and Extremely-Coarse spray according to the catalogue from their manufacturers. Applications were made with 6m a towed sprayer and boom height was 50 cm above plants and nozzle spacing was 50 cm. Each nozzle by herbicide application was replicated four times with each species, with n=576 total plants in the study. After application, pots were returned to their original growing location, and watered daily as described above. Plants were watered daily for four weeks, and ratings were taken at 7, 14, 21 and 28 days after treatment (DAT). At 28 DAT, the remaining individual plants were clipped at the soil level and put into a paper sack and placed in a drier at 65°C, dried for 48 hours, and weights were recorded. Results over both years show a distinct species by herbicide interaction, as well as a nozzle by herbicide interaction for all species except *L. rigidum*. All herbicides resulted in similar dry weight reductions with nozzles producing a Coarse or finer spray quality, showing only reduced reduction with the XC, TTI 11002. Proper nozzle selection can result in control of hard to control weed species, while reducing occurrence of spray drift.

INTRODUCING DUPONT™ SENTRALLAS™ AND DUPONT™ TRAVALLAS™ NEW LIQUID SULFONYLUREA HERBICIDES FOR CEREALS. Keith A. Diedrick*[1], Keith D. Johnson[2], Jeffrey T. Krumm[3], Bruce V. Steward[4], Robert N. Rupp[5], Kenneth L. Carlson[6]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont Crop Protection, Grand Forks, ND, [3]DuPont Crop Protection, Hastings, NE, [4]DuPont Crop Protection, Overland Park, KS, [5]DuPont Crop Protection, Edmond, OK, [6]DuPont Crop Protection, Johnston, IA (9)

No abstract submitted

SO, WHAT IS INDUSTRY DOING TO PROTECT BEES? A NON-TRADITIONAL WEED SCIENCE TOPIC. James Gifford*, David G. Ouse; Dow AgroSciences, Indianapolis, IN (10)

The sharing of manufacturing equipment (non-dedicated production facilities) during the production of crop protection products is a common practice in the industry. Non-dedicated facilities improve production efficiencies, especially when product volumes are not sufficient to warrant dedicated production lines. The consequence is that every time there is a switch from one product to the next, a thorough cleaning of the production line is required. This ensures that residues of the previously produced active ingredient are removed before the next crop protection active ingredient is produced. Dow AgroSciences is committed to ensure high quality product integrity and stewardship during manufacturing, formulation and packaging of crop protection products. The comprehensive product stewardship best practices are designed to protect non-target organisms like bees visiting crops treated with Dow AgroSciences crop protection products. This is done by determining acceptable cleaning levels (ACLs) that will prevent contamination during the product manufacturing process. Product Integrity focal points at Dow AgroSciences provide the ACLs that are then used by production managers to clean production lines at internal and external manufacturing facilities.

DOES POULTRY LITTER INFLUENCE WEED DYNAMICS IN CORN AND SOYBEANS IN WESTERN KENTUCKY? Erin Haramoto*[1], Edwin Ritchey[2], Jesse Gray[2]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky Research and Education Center, Princeton, KY (11)

Poultry litter (PL) represents a nutrient source that may also influence weed dynamics. High amounts of nitrogen released after poultry litter application may trigger a flush of weed germination, leading to higher weed density. This flush may necessitate earlier post emergence herbicide applications; increased weed density coupled with potential higher weed growth rates in response to higher N conditions in fields with a history of PL additions may reduce the efficacy of these herbicides as well. This research was conducted in western Kentucky to estimate the contribution of poultry litter to a corn/soybean rotation, in terms of yield benefit, soil quality improvements, and weed dynamics. This analysis focuses on whether weed density and size are increased prior to the time growers need to apply post emergence herbicides, and prior to harvest. This trial was conducted on four cooperating farms in 2013, 2014, and 2015. Each site rotated between corn and soybeans, and each crop was present at two sites in a given year. There were two treatments at each site—PL or nutrients supplied from synthetic fertilizer. Plots were located in the same location from year to year and litter was reapplied each spring. PL was applied at 4.3-6.1 t/ha; rates were determined to apply 70 lbs /acre of plant available N, assuming 50% availability in the initial year. Litter was surface broadcast from 1-50 days prior to planting—all fields were in no-till. Most growers used a combination of burndown (glyphosate and/or 2,4-d) and soil residual herbicides (ALS- and PPO-inhibitors being the most common for both crops, with cell division inhibitors and PSII inhibitors also used in corn) applied PRE and foliar active herbicides applied POST for weed management. The weed community was assessed prior to burndown and, in most cases, prior to POST applications and prior to harvest. Percent ground cover was estimated for the major species present, as was average plant height. Data were separated by crop and subjected to analysis of variance using treatment as a fixed factor, with site and replicate initially used as random factors. For corn, PL was associated with more weedy ground cover prior to POST application and prior to harvest but weed height was similar between treatments. For soybeans, initial analysis indicated that there were no differences in ground cover prior to POST application between the two treatments. However, the different sites were associated with a large portion of the total experimental variability (over 91%) so we analyzed sites as fixed factors to explore this source of variability. This subsequent analysis indicated that percent ground cover was higher following PL than following synthetic fertilizer, and also indicated significant differences between counties—one county had very high weedy ground cover (50%+) compared to the others. Repeated measures analysis did not detect any changes in weed ground cover or height in corn or soybeans through the three years of the study. These results suggest that PL may lead to increased weedy ground cover in both crops, and that growers should remain vigilant about scouting.

BIOLOGICALLY EFFECTIVE DOSE OF GLYPHOSATE AS INFLUENCED BY WEED SIZE IN CORN. Nader Soltani*[1], Robert E. Nurse[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Agriculture Canada, Harrow, ON (12)

There is limited information on the effect of weed size at the time of application on glyphosate efficacy in Ontario. Eleven field trials were conducted over a three-year period (2010, 2011 and 2012) in Ontario to determine the biologically effective dose of glyphosate applied postemergence (POST) at doses of 112.5 to 1350 g a.e. ha^{-1} for the control of various grass and broadleaved weed species applied when the weeds were 10-, 20- or 30-cm in height. The doses of glyphosate to reduce redroot pigweed, common ragweed, common lambsquarters, barnyardgrass and green foxtail dry weight by 50% were 118, 192, 182, 254 and 31 g a.e. ha^{-1} when applied at 10-cm weed height, 78, 13, 302, 289 and 101 g a.e. ha^{-1} when applied at 20-cm weed height and 264, 131, 123, 304 and 225 g a.e. ha^{-1} when applied at 30-cm weed height, respectively. The doses of glyphosate to reduce redroot pigweed, common ragweed, common lambsquarters, barnyardgrass and green foxtail dry weight by 90% were 353, 630, 621, 763 and 93 g a.e. ha^{-1} when applied at 10-cm weed height, 235, 201, 906, 868 and 296 g a.e. ha^{-1} when applied at 20-cm weed height and 792, 3267, 1739, 912 and 675 g a.e. ha^{-1} when applied at 30-cm weed height, respectively. Corn yields were maximized when glyphosate was applied to weeds that were up to 10-cm in height but was reduced with later glyphosate application timings which reinforces the importance of early POST weed control in corn.

VOLUNTEER CORN CONTROL IN DICAMBA &NDASH; TOLERANT SOYBEANS USING GLYPHOSATE + DICAMBA + QUIZALOFOP- P ETHYL. Larry H. Hageman*[1], Scott E. Swanson[2], Craig M. Alford[3], Keith A. Diedrick[4], Kevin L. Hahn[5], David H. Johnson[3], Keith D. Johnson[6], Jeffrey T. Krumm[7], Michael D. Meyer[3], Charles E. Snipes[8]; [1]DuPont Crop Protection, ROCHELLE, IL, [2]DuPont Crop Protection, Rochelle, IL, [3]DuPont Crop Protection, Johnston, IA, [4]DuPont Crop Protection, Madison, WI, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Grand Forks, ND, [7]DuPont Crop Protection, Hastings, NE, [8]DuPont Crop Protection, Greenville, MS (13)

No abstract submitted

CONTROL OF ENLIST CORN WITH CLETHODIM TANK-MIXED WITH ENLIST DUO. Eric J. Ott*[1], Lowell D. Sandell[2], John A. Pawlak[3]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA Corporation, Lincoln, NE, [3]Valent USA Corporation, Lansing, MI (14)

Enlist corn by Dow AgroSciences is a transgenic crop that is resistant to both 2,4-D and glyphosate. The aryloxyalkanoate dioxygenase (AAD) enzymes are responsible for conferring 2,4-D resistance in Enlist corn also act on herbicides that have a similar functional group; but from a different site of action, acetyl Co-A carboxylase (ACCase) inhibitors, and more specifically from the Aryloxyphenoxypropionate chemical family ("fops"). However, ACCase inhibitors from the Cyclohexanediones chemical family ("dims") are not affected by the AAD enzymes. When a broadleaf herbicide is applied simultaneously in a tank-mixture with an ACCase-inhibiting herbicide, there is potential for antagonism of the ACCase herbicide resulting in reduced grass control. The severity of this antagonism is dependent on the herbicide, weed species, and physiological status of the weeds. The objectives of this research were to determine if there is antagonism of clethodim when tank-mixed with Enlist Duo on controlling Enlist volunteer corn and if increasing the clethodim rate would help overcome any potential antagonism. Two trials were conducted in Lafayette, IN and Hutchinson, KS. Enlist corn was planted in 76 cm rows at a rate between 75,000 and 79,000 seeds ha^{-1}. Corn was allowed to grow to 30, 60, and 90 cm then treated with clethodim alone, Enlist Duo at 1.62 kg ae ha^{-1} with clethodim rates of 0.052 to 0.175 kg ai ha^{-1}. Visual control estimates were taken 7 and 28 DAA. Clethodim alone treatments provided the greatest control at all three application heights. Corn control was reduced when Enlist Duo 1.62 kg ae ha^{-1} was added to the spray mixture. Increasing the rate of clethodim can help overcome this reduced efficacy when tank-mixed with Enlist Duo. Higher rates of clethodim should be used when tank-mixing with Enlist Duo for control of Enlist volunteer corn.

ANTAGONISM OF CLETHODIM TANK-MIXED WITH DICAMBA OR 2,4-D: RESPONSE OF COMMON GARSS WEEDS. Kyle Russell*, Attillio Kandrotas Bercht, Mark L. Bernards; Western Illinois University, Macomb, IL (15)

No abstract submitted

WEED CONTROL, CROP TOLERANCE AND POTENTIAL TANK CONTAMINATION IN DICAMBA RESISTANT SOYBEANS. Jon E. Scott*[1], Leo D. Charvat[2], Stevan Z. Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]BASF Corporation, Lincoln, NE (16)

Weed resistance is on the increase, therefore, introduction of dicamba-tolerant soybeans could provide another option for weed control. Four studies were conducted in 2015 in northeast Nebraska, including: (1) Herbicide programs for dicamba-tolerant soybeans based on PRE followed by POST application of Engenia™ (BAPMA-dicamba); (2) efficacy of BAPMA-dicamba as influenced by weed heights; (3) tolerance of dicamba-tolerant soybeans to other auxin-type herbicides; and (4) tolerance of non-dicamba-tolerant soybeans to various levels of BAPMA-dicamba residues as potential tank contaminants. Preemergence herbicides, which included: sulfentrazone, dimethenamid-p, flumioxazin, pyroxasulfone, metribuzin, metolachlor, and saflufenacil provided good-to-excellent control of waterhemp and lambsquarters. The POST application of BAPMA-dicamba tank mixed with glyphosate provided complete control of all weed species tested. BAPMA-dicamba tank-mixed with glyphosate provide excellent control (>90%) of the weed species tested when applied early-POST and mid-POST (5-20 cm tall weeds). Late-POST application (20-30 cm weeds) was less effective, especially on velveltleaf. Dicamba-tolerant soybeans were temporarily speckled by BAPMA-dicamba+glyphosate when ultra course droplets were delivered using TTI nozzles. Dicamba-tolerant soybean sprayed with dicamba+diflufenzopyr or 2,4-D amine exhibited 90% and 75% injury levels, respectively. Non-dicamba-tolerant soybean exhibited high level of sensitivity to BAPMA-dicamba as a tank contaminant. For example, at 10DAT of BAPMA-dicamba, there was 40% injury at 1/100 of the label rate and 20% injury at 1/1000 of the label rate (560 g ai/ha) applied at V3 soybeans. Similar injury occurred with applications at V6 and R2 stages. The injuries were evident season long in the form of overall canopy stunting and leaf cupping, which further delayed crop maturity. These results indicated potential use of BAPMA-dicamba to control various weed species; however repeated use of BAPMA-dicamba alone or in combination with glyphosate should be avoided to reduce probabilities for dicamba resistance, as there is already dicamba-resistant kochia in Western Nebraska, eastern Colorado and eastern Wyoming.

HERBICIDE PROGRAMS FOR CONVENTIONAL TILL DICAMBA-TOLERANT SOYBEANS. Keith A. Diedrick*[1], Kelly A. Backscheider[2], Michael D. Meyer[3], Scott E. Swanson[4], Kevin L. Hahn[5], Keith D. Johnson[6], Jeffrey T. Krumm[7], Donald D. Ganske[8], Victoria A. Kleczewski[9], Robert W. Williams[10], Bruce V. Steward[11], Richard M. Edmund[12], Eric Castner[13], Dan Smith[14], Michael T. Edwards[15], Robert Rupp[16]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont Crop Protection, Shelbyville, IN, [3]DuPont Crop Protection, Johnston, IA, [4]DuPont Crop Protection, Rochelle, IL, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Grand Forks, ND, [7]DuPont Crop Protection, Hastings, NE, [8]DuPont Crop Protection, Winchester, VA, [9]DuPont Crop Protection, Middletown, DE, [10]DuPont Crop Protection, Raleigh, NC, [11]DuPont Crop Protection, Overland Park, KS, [12]DuPont Crop Protection, Little Rock, AR, [13]DuPont Crop Protection, Weatherford, TX, [14]DuPont Crop Protection, Madison, MS, [15]DuPont Crop Protection, Pierre Part, LA, [16]DuPont Crop Protection, Edmond, OK (17)

No abstract submitted

MONITORING FACTORS ASSOCIATED WITH THE RISK OF OFF-TARGET MOVEMENT OF SYNTHETIC AUXIN HERBICIDES IN MISSOURI. Wyatt Coffman*[1], Mandy D. Bish[2], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (18)

Historically the group 4 synthetic auxin herbicides have been more commonly associated with off-site movement and subsequent injury to non-target plants than any other class of herbicides. The impending introduction of dicamba- and 2,4-D-resistant traits into the soybean and cotton marketplace is likely to cause an increase in the usage of synthetic auxin herbicides in the near future. The focus of this research was to monitor wind speeds and surface temperature inversions, and to asses the agricultural uses of the surrounding land across five regions in Missouri to determine the potential risks associated with off-target movement of synthetic auxin herbicides. High wind speeds can lead to physical drift of herbicide particles so that the herbicide never reaches the target plants. The Missouri Historical Agricultural Weather Database was accessed to determine average hourly wind speeds over a 15-year span, from 2000 to 2015, for the months of March through August. The 15-year average hourly wind speeds for each day within a month were averaged to develop a profile of the hourly wind speeds for each month through the growing season and for five regions within the state. For four of the five regions, the typical mid-day wind speeds from March to May exceeded 14.5 km per hour, which is the wind speed that the Environmental Protection Agency (EPA) associates with elevated risk of pesticide drift. Average daily wind speeds in June varied among the regions, while all locations had the lowest average mid-day wind speeds in July and August. Surface temperature inversions have been associated with herbicide volatilization, yet little work has been done to test the frequency and intensity of such inversions. Weather stations at three regions within the state were fitted with temperature sensors at 46, 168, and 305 cm above the soil surface. Temperatures at each height were recorded every three seconds, and those temperatures were averaged for a 5-minute average temperature reading at each height. These five-minute temperatures were retrieved and compared to identify the frequency and duration of temperature inversions. Preliminary results of 2015 data in mid-Missouri indicate that inversions occurred in all five months analyzed (March through July). The longest average inversions occurred in March, averaging 14 hours per inversion and ranging in intensity from 1.7 to greater than 6.7 °C between the 46 and 305 cm sensor heights. A third factor affecting the incidence of off-target injury of synthetic auxin herbicides is the use of surrounding land. Specifically, what other types of crops or sensitive plants are growing nearby and how much of a county's land is in agriculture production? The 2007 and 2012 National Agriculture Census data were accessed to determine this information for all five regions. The land use and wind speed data were assessed using an EPA model that estimates the number of days during the growing season with a high risk of herbicide drift. The northwest region of Missouri was estimated to have 48 to 54 high-risk days through the growing season, which was more than any region analyzed. Collectively these data will be useful to equip producers with information that will help them steward these new weed control technologies. These results also support the importance of using the new, low-volatile formulations of dicamba and 2,4-D to help minimize the potential impact of temperature inversions on off-site movement through volatility.

IMPACT OF TANK CLEANING AGENTS ON AMELIORATING DICAMBA DAMAGE TO SOYBEAN (*GLYCINE MAX*). Andy J. Luke*[1], Jason W. Weirich[2], Reid J. Smeda[1]; [1]University of Missouri, Columbia, MO, [2]MFA Incorporated, Columbia, MO (19)

The advent of dicamba-tolerant soybeans creates new opportunities for improving control of herbicide-resistant weeds post-emergence, but at a potential risk for off-target injury. One concern is proper clean out of spray equipment following dicamba application, as residuals in spray solution can cause injury to subsequently treated dicamba-sensitive soybeans. At a field location in central Missouri, a study was conducted to simulate dicamba damage to sensitive soybeans due to contaminated equipment. Using two commercial sprayer systems (pulsating-pressure and constant-pressure), four tank cleaning agents were compared: water, ammonia, Cleanse®, and Erase®. Following simulated application of 0.56 kg ai/ha^{-1} dicamba, each tank cleaning product was flushed through the system with original rinsate (first rinsate) followed by two rinsates with water alone (second and third rinsate). Each rinsate was collected and applied directly on V3-V4 or R1 soybeans (76 cm row spacing). Visual injury symptoms consistent with dicamba were observed as early as one day after treatment (DAT). Across all four cleaning agents, soybean injury on V3-V4 plants at 7 DAT ranged from 6.2-6.7% with first rinsates for the pulsating pressure sprayer compared to 6.7-7.9% for the constant pressure sprayer. By 28 DAT, visual injury on first rinsate-treated plants ranged from 15.2-21.8% across both sprayer systems. Compared to the untreated plots, up to 40% plant stunting was measured for first rinsate-treated plants at 28 DAT. Damage to R1 plants was greater compared to V3-V4 plants by first rinsates at both 7 (6.2 to 13.1%) and 28 DAT (25.5 to 37%). Soybean stunting was up to 41% for R1 treated plants at 28 DAT. For V3-V4 plants, soybean injury was minimal by 28 DAT for second and third rinsates (0 to 5%). However, injury of up to 20.5% was observed on R1 plants with second and third rinsates by 28 DAT. Soybean injury was overall greater with the pulsating-pressure versus constant-pressure sprayer. A procedure for cleanout of dicamba residues from spray equipment prior to subsequent applications on sensitive soybeans is necessary for V3-V4 plants, but especially for R1 plants.

SOYBEAN RESPONSE TO PREPLANT APPLICATIONS OF DICAMBA AND DICAMBA + 2,4-D PREMIXES. Nick Fleitz*[1], JD Green[1], James R. Martin[2], Jesse Gray[3]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY, [3]University of Kentucky Research and Education Center, Princeton, KY (20)

No-till soybean producers are dependent on preplant foliar herbicides to control existing vegetation at time of planting and with an increase in glyphosate-resistant weeds such as horseweed (*Conyza canadensis*) alternative herbicide options are required. Field studies were conducted near Versailles (UKWRF) and Princeton (UKREC), Kentucky during 2014 and 2015 to evaluate the effects of preplant synthetic auxin herbicides on soybean emergence, in-season crop responses, and yield. Treatments evaluated included applications of dicamba at 280 and 560 g ae ha^{-1} (Clarity®), 2,4-D at 538 and 1076 g ae ha^{-1} (2,4-D LV4), and a pre-mixture of dicamba + 2-4-D at 88 + 538 g ae ha^{-1} and 176 + 1076 g ae ha^{-1} (Spitfire™). These treatments were applied either at time of soybean planting or 7, 14, and 30 d before planting (DBP). Application of glyphosate herbicide was also applied preplant and postemergence to maintain weed-free conditions. Effects on soybean emergence, visual crop injury and plant height reductions were not observed at either location both years for all herbicide treatments when applied 14 and 30 d before soybean planting compared to untreated plots, except soybean emergence was delayed with the dicamba + 2,4-D pre-mixture at the high rate of 176 + 1076 g ae ha^{-1} when applied 14 DBP at UKREC in 2014. Whereas, when treatments were applied at time of planting soybean emergence was delayed with the dicamba + 2,4-D pre-mixture at 88 + 538 g ae ha^{-1} and 176 + 1076 g ae ha^{-1} for all experimental sites and with 2,4-D alone at 538 and 1076 g ae ha^{-1} at UKREC in 2015. When applied at 7 DBP emergence was also delayed at both locations in 2014 with the dicamba + 2,4-D pre-mixture at 176 + 1076 g ae ha^{-1} and dicamba at 280 g ae ha^{-1}. Across all experimental sites visual crop injury was observed four wk after planting with the dicamba + 2,4-D premix at 88 + 538 g ae ha^{-1} (which ranged from 8 to 50%) and the dicamba + 2,4-D pre-mixture at 176+1076 g ae ha^{-1} (25 to 70%) when applied at planting. When applied at 7 DBP, 5 to 19% visual injury was observed with applications of the dicamba + 2,4-D pre-mixture at 176+1076 g ae ha^{-1} at three of the experimental sites and 5 to 6% visual injury with dicamba alone at 280 g ae ha^{-1} at both locations and years. At UKREC 2014 time of planting applications of the dicamba + 2,4-D pre-mixture at 88 + 538 g ae ha^{-1} and dicamba + 2,4-D premix at 176+1076 g ae ha^{-1} resulted in 8% and 17% reduction in soybean plant height, respectively, and 10% and 20% plant height reduction at UKWRF 2015. When applied at seven DBP dicamba at 280 g ae ha^{-1}, 2,4-D at 54 and 176 g ae ha^{-1}, and dicamba + 2,4-D premix treatments did not reduce plant height. No height differences were observed at UKWRF in 2014 and UKREC in 2015 for all treatments. Differences observed in early season soybean responses across experimental sites at time of planting and seven DBP with synthetic auxin herbicides can be associated with herbicide application rate and limited rainfall (<2.54 cm) which occurred at UKREC 2014 and UKWRF 2015 between time of herbicide application and planting. Soybean yield did not differ between preplant herbicide treatments and untreated plots at UKWRF 2014 or UKREC 2015. Whereas, at UKREC in 2014 and UKWRF in 2015 soybean yield was reduced by dicamba + 2,4-D pre-mixture at the high rate of 176+1076 g ae ha^{-1} when applied at time of planting. Treatments with 2,4-D alone applied at time of planting and all other treatments applied at 7, 14 and 30 DBP did not affect crop yields.

RESPONSE OF SOYBEAN FOLLOWING THE APPLICATION OF LACTOFEN, GIBBERELLIC ACID AND FOLIAR NUTRIENT COMBINATIONS. Lowell D. Sandell*[1], Kevin D. Forney[2]; [1]Valent USA Corporation, Lincoln, NE, [2]Valent USA, Bakersfield, CA (21)

Soybean phototoxic response from a postemergence application of lactofen is often considered undesirable for many farmers. This trial investigated the potential for utilizing plant growth regulators and foliar fertilizer to enhance growth of soybeans after an application of lactofen. The trial design was a randomized complete block design with three replications. Treatments were applied to V4 soybeans. Treatments consisted of an untreated control and lactofen and gibberellic acid (GA3) alone and in combination. At three WAA, lactofen reduced plant height, while GA3 alone and in combination with lactofen increased plant height compared to lactofen alone. Nodal development of the lactofen treatment was approximately one half of a node behind the untreated control. Nodal development in GA3 treatments was equivalent to the untreated control. At six WAA, treatments with GA3 were taller than the untreated and lactofen treatments, however nodal development did not differ between treatments. The addition of GA alone and applied in combination with lactofen increased yield compared to the untreated control and lactofen alone treatments.

CONYZA CANADENSIS CONTROL PROGRAMS IN ENLIST SOYBEAN. Kristin Rosenbaum*[1], David Simpson[2], Leah Granke[3], Laura A. Campbell[4], Marcos Baez Buchanan[5]; [1]Dow AgroSciences, Crete, NE, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Columbus, OH, [4]Dow AgroSciences, Carbonale, IL, [5]Dow AgroSciences, Entre Rios, Argentina (22)

The Enlist™ weed control system has been developed in multiple crops including Enlist soybean and Enlist E3™ soybean to target hard to control and/or glyphosate-resistant weed species. 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. Research was initiated in 2013 utilizing the Enlist weed control system to characterize glyphosate-resistant (Gly-R) horseweed *Conyza canadensis* control in the Midwest with applications of Enlist Duo™ herbicide in Enlist E3 soybeans. Thirty studies were conducted from 2013 through 2015 to characterize the level of weed control delivered by a systems approach comprised of a burndown followed by postemergence application. Burndown treatments were applied approximately 14 days before planting with or without herbicides with soil residual properties including Sonic® herbicide (cloransulam + sulfentrazone) at 220 g ae/ha or flumioxazin + chlorimuron at 62.7 + 21.6 g ai/ha. The selected soil residual herbicide was tank-mixed with glyphosate at 1680 g ae/ha, Enlist Duo herbicide (2,4-D choline + glyphosate) at 1640 and 2185 g ae/ha, or glufosinate at 542 g ae/ha. Additional burndown treatments included 2,4-D + glufosinate at 1065 + 542 g ae/ha, glyphosate + dicamba at 1680 + 560 g ae/ha, and flumioxazin + chlorimuron at 62.7 + 21.6 g ai/ha tank-mixed with glyphosate + dicamba at 1680 + 560 g ae/ha. Postemergence applications included Enlist Duo at 1640 and 2185 g ae/ha, glyphosate at 1680 g ae/ha, glufosinate at 542 g ae/ha, 2,4-D + glufosinate at 1065 + 542 g ae/ha and glyphosate + dicamba at 1680 + 560 g ae/ha applied at the V3 stage of soybean growth. Results four weeks following the burndown application indicate the addition of residual herbicide with Enlist Duo increased Gly-R horseweed control to 97% compared to 90% control with Enlist Duo alone. Four weeks following the V3 application, sequential applications of Enlist Duo provided control equivalent to two applications of glyphosate + dicamba; 2,4-D choline with glufosinate at burndown or V3 timings provided better control than glufosinate alone. The addition of Sonic or flumioxazin + chlorimuron to Enlist Duo or glyphosate + dicamba in the burndown application followed by V3 application of Enlist Duo or glyphosate + dicamba provided 99% Gly-R horseweed control. The Enlist weed control system provides control greater than or equivalent to the current industry standards for glyphosate-resistant horseweed in US Midwest soybeans.

PALMER AMARANTH CONTROL OPTIONS IN ENLIST SOYBEAN. Michael Moechnig*[1], Kristin Rosenbaum[2], Leah Granke[3], Larry Walton[4], Bobby Haygood[5], Sunil Tewari[6]; [1]Dow AgroSciences, Toronto, SD, [2]Dow AgroSciences, Crete, NE, [3]Dow AgroSciences, Columbus, OH, [4]Dow AgroSciences, Tupelo, MS, [5]Dow AgroSciences, Memphis, TN, [6]Dow AgoSciences, West Lafayette, IN (23)

Palmer amaranth (*Amaranthus palmeri*) has become problematic in soybeans partially due to populations that are resistant to multiple herbicide modes-of-action (MOA), extended emergence relative to other weed species, and an expanding geographic range. Glyphosate-resistant biotypes can be managed in glyphosate-tolerant soybeans, but there is often a heavy reliance on PPO-inhibiting herbicides that may increase selection for resistance to that MOA and threaten the sustainability of current programs. Enlist™ soybeans provide opportunities to use utilize two different MOAs, including 2,4-D choline (group 4) and glufosinate (group 10), within current glyphosate-based weed control programs to provide greater flexibility of control options, more consistent control, and more sustainable weed control programs. From 2012 to 2015, 23 trials were conducted at sites from Michigan to Mississippi to evaluate the efficacy of different herbicide programs that may be used in Enlist™ soybeans to control Palmer amaranth. All herbicide programs included a soil residual pre-emergence herbicide (PRE), followed by one or two postemergence (POST) applications of Enlist Duo™ herbicide, one or two applications of glufosinate + 2,4-D choline, Enlist Duo™ followed by glufosinate or glufosinate followed by Enlist Duo™, or soil residual herbicides applied POST with Enlist Duo™ or glufosinate+2,4-D choline. The POST herbicides were applied to Palmer amaranth < 10 cm tall. The PRE herbicides, Sonic® (sulfentrazone + cloransulam, 136.6 + 17.5 g ai/ha) and Surveil® (flumioxazin + cloransulam, 71.5 + 23.5 g ai/ha), provided greater than 90% control up to 28 d after application (DAA), but control declined and became more variable thereafter. Single applications of Enlist Duo™ (glyphosate + 2,4-D choline, 1,120 g ae/ha + 1,065 g ae/ha) or glufosinate (542 g ae/ha) + 2,4-D choline (1,065 g ae/ha), applied 28 days after the PRE, resulted in approximately 95% control 14 DAA, but control declined to approximately 91% by 42 DAA. Adding a soil residual herbicide (S-metolachlor 1,070 g ai/ha) with the single POST application increased control to 95-96% 42 DAA. Control at this time was increased to 97-98% if Enlist Duo™, glufosinate + 2,4-D choline, or glufosinate was applied 14 days after the first POST application. Control was similar (97-98%) if Enlist Duo™ was applied prior to glufosinate or if glufosinate was applied prior to Enlist Duo™. Relative to current standard Palmer amaranth control programs, there are several new and effective herbicide programs for Enlist™ soybeans that include multiple MOAs to provide a more sustainable approach to control Palmer amaranth by minimizing selection for herbicide resistance.

CONTROL OF *AMARANTHUS SPP.* IN DOUBLE CROP SOYBEAN. Marshall M. Hay*, Dallas E. Peterson, Doug E. Shoup; Kansas State University, Manhattan, KS (24)

Double crop soybean after wheat is a component of many cropping systems across eastern and central Kansas. Until recently, weed control of *Amaranthus spp*, particularly *Amaranthus palmeri*, has been both easy and economical through the use of sequential applications of glyphosate in Roundup Ready soybean. However, due to this management approach, many populations of *Amaranthus spp.* in Kansas have become resistant to common use rates of glyphosate, which calls for a step-change in management. Field experiments were established in 2015 near Manhattan and Hutchinson, Kansas, to assess 13 non-glyphosate herbicide programs for control of *Amaranthus spp.* in a double crop soybean after wheat cropping system. Emergence of *Amaranthus spp.* begins in April in southern Kansas. Therefore, spring post treatments of pyroxasulfone and pendimethalin were applied to the wheat at Feekes 6 to evaluate residual *Amaranthus spp.* ahead of double crop soybean. Additionally, a two week pre-harvest treatment of 2,4-D was applied to the wheat to assess burndown control of existing *Amaranthus spp.* in the wheat crop. At both sites after wheat harvest, very poor control of *Amaranthus spp*. was observed in the spring post treatments as well as the pre-harvest treatment. Wheat harvest, soybean planting, and postharvest/preemergence herbicide treatments occurred within 24 hours at both locations. Excellent control was observed at one WAT for a postharvest paraquat application; however, reduced control was noted at eight WAT due to extended emergence of *Amaranthus spp.* *Amaranthus spp.* control was 85% or greater at four and eight WAT for postharvest treatments that included a combination of paraquat plus residual herbicides when a high level of burndown control was achieved following application. Postharvest treatments that did not include paraquat or had poor wheat residue distribution which effected herbicide coverage did not provide acceptable control.

EVALUATION OF NEW HERBICIDE TOLERANT CROPS: BOLT BEANS AND BALANCE BEANS. Stevan Z. Knezevic*[1], Jeffrey T. Krumm[2], Kevin Watteyne[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]DuPont Crop Protection, Hastings, NE, [3]Bayer CropScience, Lincoln, NE (25)

Weed resistance is on the increase in corn and soybean, therefore, alternative weed control tools are needed. Introduction of Balance™ GT technology by Bayer and Bolt™ technology by DuPont could provide another option for weed control in soybeans, therefore both soybean types were field tested in 2015 in northeast Nebraska. A study with Bolt™ soybeans contained various PRE herbicides followed by POST applications of ALS-inhibiting herbicides including: chlorimuron, thifensulfuron, and imazethapyr + fomesafen. Field studies with HPPD-tolerant soybean were conducted in 2015 with isoxaflutole (Balance® Bean) and metribuzin applied PRE, while there were various POST combinations including: imazethapyr + fomesafen, glufosinate, glyphosate, pyroxasulfone, and fomesafen + glyphosate. Bolt™ soybeans exhibited good tolerance to all ALS-inhibiting herbicides tested. Most herbicide programs tested in Bolt™ soybeans provided good-to-excellent control (80-100%) of local weed species, including green foxtail, waterhemp, and velvetleaf for six-eight wk. For example, chlorimuron + flumioxazin + rimsulfuron PRE followed by chlorimuron + glyphosate + thifensulfuron provided excellent (>90%) weed control. HPPD-tolerant soybean exhibited excellent tolerance to isoxaflutole applied PRE at 70 and 105 g ai/ha. Most herbicide programs tested in HPPD-tolerant soybeans provided good-to-excellent control (80-100%) of local weed species, including green foxtail, waterhemp, and velvetleaf for six-eight wk. For example, isoxaflutole + metribuzin PRE followed by glufosinate + pyroxasulfone POST provided excellent weed control and extended residual. These results indicate potential use of Bolt Beans and isoxaflutole to control glyphosate resistant waterhemp. Considering that there are already HPPD-ALS-glyphosate-resistant weeds, a repeated use of isoxaflutole alone, or ALS-inhibiting herbicides alone, or their combinations with glyphosate should be avoided. Their use should be carefully managed as part of the Best Management Practice and Stewardship Programs for both HPPD-tolerant and Bolt Beans.

BOLT™ TECHNOLOGY SOYBEANS FOR IMPROVED PLANT-BACK FLEXIBILITY AFTER DUPONT™ FINESSE® HERBICIDE APPLICATION TO WHEAT. Kelly A. Backscheider*[1], Larry H. Hageman[2], Jeffrey T. Krumm[3], Scott E. Swanson[4], Bruce V. Steward[5], Michael T. Edwards[6], Robert N. Rupp[7], Robert W. Williams[8], Richard M. Edmund[9], Victoria A. Kleczewski[10], David H. Johnson[11]; [1]DuPont Crop Protection, Shelbyville, IN, [2]DuPont Crop Protection, ROCHELLE, IL, [3]DuPont Crop Protection, Hastings, NE, [4]DuPont Crop Protection, Rochelle, IL, [5]DuPont Crop Protection, Overland Park, KS, [6]DuPont Crop Protection, Pierre Part, LA, [7]DuPont Crop Protection, Edmond, OK, [8]DuPont Crop Protection, Raleigh, NC, [9]DuPont Crop Protection, Little Rock, AR, [10]DuPont Crop Protection, Middletown, DE, [11]DuPont Crop Protection, Johnston, IA (26)

No abstract submitted

GLUFOSINATE (LIBERTYLINK) AND GLYPHOSATE (ROUNDUP READY/GT) WEED CONTROL PROGRAMS FOR SOA 2- AND SOA 9-RESISTANT GIANT RAGWEED IN SOYBEAN. Lisa M. Behnken*[1], Fritz R. Breitenbach[2], Jeffrey L. Gunsolus[3]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota Extension, St. Paul, MN (27)

With the increase in herbicide-resistant weed biotypes and no new herbicide chemistries on the horizon, fewer options remain for good weed control. Achieving acceptable weed control is particularly challenging in parts of Minnesota where giant ragweed *Ambrosia trifida* is resistant to both SOA 2- (ALS inhibitors) and SOA 9- (EPSP synthase inhibitors) herbicides. Research conducted in Rochester, Minnesota, in 2015 suggests that Liberty (glufosinate) herbicide can be a viable control option when herbicide-resistant giant ragweed is present. Glufosinate and glyphosate systems were compared in soybean where giant ragweed populations were resistant to both SOA 2- and SOA 9- herbicides. A randomized complete block design was used with four replications. Three types of applications were made in both the glufosinate and glyphosate systems: 1) Preemergence application (PRE) followed by postemergence (POST) application(s) of glufosinate or glyphosate. In the glufosinate system, two POST applications of glufosinate were made; 2) Two-pass POST applications of glufosinate or glyphosate with effective tank-mix partners; and 3) Two-pass POST applications of glufosinate or glyphosate without tank-mix partners. PRE treatments and POST systemic herbicide treatments (e.g. glyphosate) were applied with TTI11002 spray tips. POST contact herbicide treatments (e.g. glufosinate) were applied with TTIJ60-11002 spray tips. Applications were applied with a tractor-mounted sprayer delivering 15 gpa (141 l/ha) at 30 psi (207 kpa). Evaluations of the plots were taken nine times from June through September. In this study, the most effective weed control was the glufosinate system that used a PRE herbicide (active on giant ragweed) followed by two timely (5 cm weeds) POST applications of glufosinate, since weed species other than giant ragweed (e.g. common waterhemp) also needed to be controlled. In addition to good weed control, it also had among the lowest herbicide injury ratings throughout the season. In the glyphosate systems, the inclusion of a SOA 14 (PPO inhibitor) herbicide was essential for giant ragweed control. However, overuse of SOA 10 (glufosinate) and SOA 14 (PPO inhibitors) herbicides is a concern and could result in giant ragweed becoming resistant to both of these SOAs. A diversified weed management plan is essential for maintaining herbicide effectiveness and minimizing the risk of resistance development. It is becoming evident that herbicide-only management systems to control resistant weed populations are going to be increasingly challenged and non-chemical strategies will need to be implemented.

CONTROL OF GLYPHOSATE-RESISTANT COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L) IN GLUFOSINATE-RESISTANT SOYBEAN. Ethann R. Barnes*[1], Peter H. Sikkema[2], Stevan Z. Knezevic[3], John L. Lindquist[1], Amitkumar J. Jhala[4]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Guelph, Ridgetown, ON,

[3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska-Lincoln, Lincoln, NE (28)

Common ragweed is a competitive weed in soybean that emerges from mid-April through May in Nebraska. Therefore, the use of preplant herbicide is critical for effective control of common ragweed. Glyphosate-resistant common ragweed has recently been confirmed in Nebraska. Glufosinate is an alternative herbicide option for control of glyphosate-resistant weeds in glufosinate-resistant soybean. A field experiment was conducted on a grower's field infested with glyphosate-resistant common ragweed in Gage County, NE in 2015. The objective was to evaluate the efficacy of preplant herbicides followed by glufosinate applied alone or in tank-mixture for control of glyphosate-resistant common ragweed in glufosinate-resistant soybean. Most of the herbicides applied preplant provided ≥ 96% control of common ragweed at 21 d after treatment. Sulfentrazone plus metribuzin applied PRE resulted in 15% control of common ragweed at 21 days after PRE compared to ≥ 74% control with preplant herbicides. A POST application of glufosinate after preplant or PRE herbicides was effective and resulted in ≥ 84% control. Herbicides applied preplant followed by a POST application of glufosinate resulted in season-long control (≥ 93%) of common ragweed, reduced common ragweed biomass by more than 88%, and resulted in soybean yields of more than 1,588 kg ha^{-1}. This study shows the importance of using preplant herbicide and also confirms that their use followed by glufosinate alone or in tank-mixture provides season long control of glyphosate-resistant common ragweed in glufosinate-resistant soybean.

S.T.O.P WEEDS WITH GLUFOSINATE - BEST MANAGEMENT PRACTICES. Aaron M. Helbling*[1], Kevin B. Thorsness[1], Angela J. Kazmierczak[1], John B. Christianson[1], Bill Shores[2], Arlene Cotie[3]; [1]Bayer CropScience, Fargo, ND, [2]Bayer CropScience, Fergus Fall, MN, [3]Bayer Crop Science, Raleigh, NC (29)

Glufosinate-ammonium is a non-selective, non-residual, contact postemergence herbicide that has been developed by Bayer CropScience for use in glufosinate-ammonium tolerant traited crops such as soybean, canola, corn, and cotton. Proper product stewardship is necessary to ensure effective weed control and long-term sustainability of glufosinate-ammonium. Therefore, Bayer CropScience has implemented the S.T.O.P. weeds with glufosinate-ammonium guidelines. The S.T.O.P. guideline initials represent; Start clean and Stay clean by controlling emerged weeds prior to planting and controlling escapes throughout the season, Target weeds that are < 7.6 cm tall, Optimize coverage with the correct application parameters, and Pair glufosinate-ammonium with residual herbicides. To demonstrate the benefits of the S.T.O.P. guidelines, a trial was established in a commercial soybean field during the summer of 2015. Each treatment consisted of 16.2 hectares, the treatments were not replicated, and the treatments were applied by the grower using commercial application equipment. The treatments compared glufosinate-ammonium applied based on the S.T.O.P. guidelines and glufosinate-ammonium applied using typical glyphosate application parameters. Weed control differences were observed visually during the growing season. Additionally, game trail cameras were established in each treatment to record differences in weed control among the treatments. The information collected from this trial was used to build localized glufosinate-ammonium S.T.O.P. positioning tools to be used with producers, agronomists, and consultants.

USE OF WEED SCREENS TO EVALUATE PRE AND POST HERBICIDE CONCEPTS IN SOYBEAN. Stevan Z. Knezevic*[1], David A. Feist[2], Steve Eskelsen[3], Jon E. Scott[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]ADAMA, Fort Collins, CO, [3]ADAMA, Kennewick, WA (30)

Weed resistance is increasing across all major cropping systems in USA, including an evolution and development of so called "super weeds". Therefore there is an urgent need for alternative weed control tools, including development and testing of new herbicides or pre-mixtures of various active ingredients. We believe that utilizing weed screening methodology can aid and speed up the development of new premixes and new herbicide programs for major crops. Therefore, field studies were conducted in Nebraska during 2014 and 2015 seasons with the objective to test various herbicide pre-mixtures for control of 11 major weeds in soybean. Locally collected seeds of 11 weed species were planted perpendicular to the crop rows after soybean planting. The list of weed species included four grasses: yellow foxtail, green foxtail barnyardgrass, fall panicum; and seven broadleaves: ivyleaf morningglory, kochia, common lambsquarters, redroot pigweed, Venice mallow, common waterhemp and velvetleaf. Variety of new pre-mixtures were applied PRE or POST, including: metolachlor + imazethapyr, metolachlor, imazethapyr, fomesafen, fomesafen + imazethapyr, flumioxazin+imazethapyr , flumioxazin, flumioxazin + metribuzin, and metribuzin. In general, pre-mixtures of PRE herbicides provided overall better weed control compared to POST. For example, PRE application of metolachlor + imazethapyr provided excellent control (>90%) of all grassy and broadleaf species, except ivyleaf morningglory and common waterhemp. Flumioxazin + imazethapyr or flumioxazin + metribuzin also provided good weed control (>85%) of most species, except ivyleaf morningglory. In contrary, weed control with POST herbicides were lower than PRE, and much more variable. For example, POST application of metolachlor + imazethapyr provided about 80% control of green and yellow foxtail, kochia, lambsquarters and redroot pigweed compared to a much lower control (<50%) of other species. A similar trend was evident with other POST treatments.

INTRODUCTION OF SURVEIL® HERBICIDE FOR PREPLANT AND PREEMERGENCE WEED CONTROL IN SOYBEAN. Joe Armstrong[1], Jeffrey Ellis*[2], Chris Voglewede[3], Mark Peterson[3]; [1]Dow AgroSciences, Davenport, IA, [2]Dow AgroSciences, Sterlington, LA, [3]Dow AgroSciences, Indianapolis, IN (31)

Surveil® herbicide is a new pre-mixture of cloransulam-methyl and flumioxazin (48% water dispersible granule formulation: 12% cloransulam-methyl + 36% flumioxazin) for preemergence weed control in soybean. This formulation has improved handling and mixing properties, such as rapid dispersion when mixed in water. Comprised of active ingredients from two modes-of-action (WSSA Group 2 and Group 14), Surveil provides long lasting, broad-spectrum residual control of many herbicide-resistant and hard-to-control weeds. In 42 field trials conducted across the Midwest and mid-South in 2013 through 2015, Surveil provided >90% control of several key weeds, including waterhemp, Palmer amaranth, giant ragweed, velvetleaf, and morningglory species, at use rates from 71 to 141 g ai/ha (2.1 to 4.2 oz/acre of formulated product) across a range of geographies and soil conditions. Additionally, Surveil offers flexible application timings for fall, preplant burndown, and preemergence weed control, favorable rotation intervals to many key crops, and crop tolerance comparable to other industry herbicide standards. Surveil received federal registration in May 2015 and will be available for use for the 2016 growing season.

MANAGING WATERHEMP IN SOYBEANS WITH LAYERED RESIDUAL HERBICIDES. A STRATEGY FOR CONTROLLING GLYPHOSATE RESISTANT WATERHEMP IN MINNESOTA. Lisa M. Behnken*[1], Fritz R. Breitenbach[2], Jeffrey L. Gunsolus[3]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota Extension, St. Paul, MN (32)

The objective of this trial was to evaluate and demonstrate the effectiveness of layering soil residual herbicides for control of waterhemp in soybeans in southeastern Minnesota. Common waterhemp *(Amaranthus rudis)* is becoming more widespread throughout Minnesota. In addition, waterhemp populations resistant to glyphosate (SOA-9) are increasing and most populations are already ALS (SOA-2) resistant. When glyphosate is no longer effective, other strategies to control waterhemp are needed. One strategy for dealing with glyphosate resistant waterhemp is to layer soil residual herbicides, preemergence (PRE) followed by additional residual herbicide at early postemergence (POST). Waterhemp seedlings emerge over an extended period of time, frequently outlasting the residual control achieved by herbicides applied before planting or crop emergence. Several residual herbicides may be applied post-emergence to the crop alone or in combination with other post emergent herbicides. When activated by rainfall, these post-applied residual herbicides can extend the duration of waterhemp seedling control. Three herbicides were evaluated in this study, 1) Dual II Magnum (s-metolachlor) at 1.5 pts/A PRE only or 1.5 pts/A PRE followed by 1.0 pt/A POST, 2) Outlook (dimethenamid-P) at 18 fl oz/A PRE only or 14 fl oz/A PRE followed by 10 fl oz/A POST, and 3) Warrant (acetochlor) at 1.6 qt/A PRE only or 1.6 qt/A PRE followed by 1.6 qt/A POST. These were selected because of their known effectiveness for controlling waterhemp and their flexibility of application timing. Rates used were based on soil type and seasonal limits. Pursuit (imazethapyr) did not control this population of waterhemp (ALS resistant); however, it was applied in tank mixtures with the preemergence herbicides to eliminate other broadleaf weeds. A randomized complete block design was used with three replications. Preemergence treatments were applied at planting on May 5, 2015. Layered soil residual products were applied post emergence, 34 days after preemergence herbicides were applied. Evaluations of the plots were taken from May through September. Layered or sequential applications of Dual II Magnum, Outlook, or Warrant herbicide provided significantly better, (95, 94, and 90% respectively) season-long control of waterhemp compared to their PRE only treatments (81, 71, and 62%, respectively), at the September 29, 2015 rating.

SEASON-LONG CONTROL OF GLYPHOSATE-RESISTANT COMMON WATERHEMP AS INFLUENCED BY SPLIT-APPLICATIONS OF VERY LONG CHAIN FATTY ACID SYNTHESIS INHIBITORS IN SOYBEAN. Debalin Sarangi*[1], Lowell D. Sandell[2], Stevan Z. Knezevic[3], John L. Lindquist[4], Suat Irmak[1], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Valent USA Corporation, Lincoln, NE, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska- Lincoln, Lincoln, NE (33)

Widespread adoption of glyphosate-tolerant crops encouraged growers to apply single active ingredient, glyphosate, on the top of the crop-canopy; reducing the use of several soil-applied herbicides. Common waterhemp (*Amaranthus rudis* Sauer) has an extended period of emergence in the growing season; therefore, preemergence (PRE) or early postemergence (POST) herbicide applications may not be effective at controling the later emerging common waterhemp flushes. Several very long chain fatty acid (VLCFA) inhibitors have substantial soil-residual activity and have been registered for sequential applications (as POST) in soybean. The objectives of this study were to compare the efficacy of VLCFA-inhibiting herbicides applied at a recommended full rate or in split applications for season-long control of glyphosate-resistant common waterhemp. Field experiments were conducted in 2013 and 2014 in Dodge County, NE, in a field infested with glyphosate-resistant common waterhemp. Micro-encapsulated acetochlor or pyroxasulfone at recommended full rate resulted in ≥ 94% control and reduced common waterhemp density up to one plant m^{-2} at 15 d after PRE. Averaged across herbicide programs, common waterhemp control was 83% with density of 15 plants m^{-2} at harvest with VLCFA inhibitors applied PRE at full labeled rate, compared with 77% control and 31 plants m^{-2} at that time with sequential application of these herbicides at reduced rate. Results of this study also indicated that single application of acetochlor resulted in highest soybean yield (2,261 kg ha^{-1}), which was comparable to yield (>2,070 kg ha^{-1}) obtained in PRE applications of dimethenamid-P or pyroxasulfone. In summary, several VLCFA inhibitors applied as PRE can be considered a good option for management of glyphosate-resistant common waterhemp in soybean.

HAS SOYBEAN BREEDING OVER 80 YEARS SELECTED FOR INCREASED COMPETITIVENESS WITH WEEDS? Devin Hammer*, Shawn Conley; University of Wisconsin-Madison, Madison, WI (34)

Soybean yield gain over the last century has been attributed to both genetic and agronomic improvements over time. Recent research has characterized how breeding efforts to improve yield gain have also secondarily impacted agronomic decisions such as seeding rate, planting date, and fungicide use. However, no research has characterized the relationship between weed-crop interference and genetic yield gain. Therefore, the objective of this research was to determine if soybean breeding efforts over time have indirectly affected crop competitiveness. This study was conducted in 2014 and 2015 at the University of Wisconsin Arlington Agricultural Research Station. The experimental design was a randomized complete block in a split-plot arrangement with three replications. The whole plot factor was three different seeding rates (0, 2.8, and 11.2 seeds m^{-2}) of our model weed species, volunteer corn. Volunteer corn was used due to its high level of competitiveness and regular occurrence in Midwestern soybean fields. The sub-plot factor consisted of 40 maturity group II soybean varieties released from 1928 to 2014. In 2014 and 2015 soybean seed yield data were collected from each plot. Because soybean samples contained both volunteer corn and soybean seed, subsamples were collected and sorted to quantify the percentage of soybean and volunteer corn seed yield by mass for each plot. In 2015, soybean and volunteer corn height and width data were collected on three plants $plot^{-1}$ to characterize plant growth. Above-ground dry biomass subsamples were collected on the three corn plants at R8 soybean. In 2014, soybean seed yield increased linearly 11.3 kg ha^{-1} yr^{-1} over cultivar release year across three weed population densities ($P = 0.02$). Slopes did not differ among weed population densities ($P = 0.52$). Regression analysis also indicated that cultivar release year had no effect on weed biomass at either established weed population density, 2.8 or 11.2 seeds m^{-2} ($P = 0.88$ and $P = 0.74$, respectively.) Preliminary results suggest that breeding efforts have not influenced the competitive ability of soybean.

SOYBEAN YIELD AS AFFECTED BY PLANTING DATE AND RELATIVE REMOVAL TIME OF COVER CROP OR WINTER ANNUAL WEEDS. Kristina Simmons*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (35)

No abstract submitted

WEED MANAGEMENT TECHNIQUES FOR ORGANIC SOYBEANS (*GLYCINE MAX*). Ricardo C. Silva*, Carey F. Page, Reid J. Smeda; University of Missouri, Columbia, MO (36)

Management of summer annual weeds is a major limitation to successful production of organic soybeans. Although tillage is the most dominant weed control technique, sustainable production must encompass other methods. This research is part of a multi-year study to compare tillage, flame cultivation, mowing, and hot water for in-season weed control in soybeans. In central Missouri, an OMRI approved area was tilled and planted (76 cm rows) on June, 26th, 2015. As weeds initially reached 10 cm, weed control practices were implemented and repeated on the same plots 1-2 times weekly until canopy closure. Weed density and plant biomass by species were recorded throughout the season to estimate treatment effectiveness. Thirty-one days after planting (DAP), hot water suppressed grasses more effectively that of other treatments, with biomass following flame cultivation 3.4-fold higher. However, flame cultivation was most effective on broadleaves and least effective with hot water (9-fold higher biomass). By 56 DAP, grass biomass in hot water treated areas was highest, and 12.5-fold higher than the most effective treatment (cultivation). Biomass of broadleaf weeds was also highest following hot water use, with no broadleaf weeds detected in flame cultivation and mowed areas. Due the excessive rainfall, grasses continued to be predominant, resulting in no detectable broadleaf weeds at 90 DAP. Among treatments, grass biomass was highest in flame cultivation versus mowed areas (4.7–fold) and the order from greatest to least biomass was flame cultivation > cultivation > hot water > mowing. Flame cultivation resulted in soybean injury, opening up the crop canopy and permitting weed encroachment. Excessive rainfall precluded the effectiveness of cultivation, as grasses re-rooted and continued to develop. Hot water offers some promise to reduce weed biomass, but thorough coverage of treated plants is critical. Although cultivation is a widely accepted practice for weed control in organic soybeans, other practices show promise.

METHODS FOR ASSESSING RAINFASTNESS OF HERBICIDE / SAFENER COMBINATIONS. David G. Ouse*[1], Roger Gast[1], James Gifford[1], Andrea McVeigh[1], Debbie Bingham-Burr[2]; [1]Dow AgroSciences, Indianapolis, IN, [2]Kelly Scientific, Indianapolis, IN (37)

Rainfastness of a pyroxsulam + CQC-mexyl liquid oil dispersion (OD) and a pyroxsulam + CQC-acid wettable granule (WG) was compared when applied to spring wheat, durum wheat and wild oats at the 2 to 4 leaf stages. A track sprayer fitted with an 8003E flat fan nozzle was utilized to apply a simulated rain by making successive passes over herbicide-treated plant material. Simulated rain of 13 mm (0.5 inches) over 20 minutes was applied at 1, 2, 4 and 6 hours after treatment (HAT) and compared to treatments where no rain was applied. Spring wheat injury (< 5%) was similar when pyroxsulam was applied with OD or CQC acid WG formulations at all rainfall timings 21 d after treatment (DAA). Injury to durum wheat was generally more pronounced with both formulations. The degree of injury was not affected by safener form or any rainfall event after treatment. Both the pyroxsulam CQC-mexyl and CQC-acid formulations were rainfast at 2 HAT and the level of control of wild oats was 71 and 95% respectively. Whereas wild oat control when no rain was applied was 86 and 84%, respectively, for pyroxsulam CQC-mexyl and CQC-acid formulations. CQC-acid can be utilized to safen pyroxsulam in cereals and maintain good rainfastness.

ESTABLISHING DRIFT REDUCTION RATINGS FOR GROUND NOZZLES AND TANK-MIXTURES USING THE EPA&RSQUO;S GUIDELINES. Ryan S. Henry*[1], William E. Bagley[2], Jerome J. Schleier III[3], Patrick L. Havens[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Bagley Enterprises, San Antonio, TX, [3]Dow AgroSciences, Indianapolis, IN (38)

The introduction of the Drift Reduction Technology (DRT) guidelines by the United States Environmental Protection Agency (EPA) has established testing protocols for spray nozzles, tank-mixtures, and application methods, and these guidelines are intended to reduce the off-target movement of agrochemicals. Inherent with any new guideline or protocol, questions and areas of improvement are raised. The Pesticide Application and Technology Laboratory in North Platte, Nebraska, USA has developed a large database of droplet spectrum data in regards to agrochemical applications by ground systems. The current dataset was completed using the guidelines of the U.S. EPA, while following in-house standard operating procedures. Data were collected from a combination of three nozzle categories, two operating pressures, and six tank-mixtures. Nozzle selection accounted for approximately 70 % of the database variation of the tested parameters. At spray categories of Extremely Coarse and Ultra Coarse, the effect of operating pressure and tank-mixture was non-existent. This dataset has the potential to guide future decision making processes by the EPA and the agriculture industry for drift reduction technologies.

EFFECT OF SPRAY DROPLET SIZE ON RAINFASTNESS OF GLYPHOSATE (ROUNDUP POWERMAX) APPLIED TO VELVETLEAF, COMMON LAMBSQUARTER AND GRAIN SORGHUM. Jeffrey A. Golus*[1], Chandra J. Hawley[2], Desarae Catlett[2], Greg R. Kruger[2]; [1]University of Nebraska, Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE (39)

Applicators are under extreme pressure to make applications of lots of hectares in a short period of time, often less than a few weeks. Because of this, there is often temptation to apply products in less than optimal conditions which can potentially result in reduced weed control, selection for resistance or the need make subsequent applications. Though forecasters try to predict the weather, precipitation events can occur on very short notice, thus rainfastness recommendations are placed on the labels with the guidelines on what is needed so product efficacy is not lost. Applicators want the products to be cost-effective, stay on the plant surface, kill the weed and not dilute or runoff. Evaluations of pesticide rain fastness technologies is critical to producers and applicators. A laboratory experiment was conducted at the University of Nebraska Pesticide Application and Technology Laboratory in North Platte, NE. The objective was to evaluate the effect of spray droplet size on the length of rainfast period of glyphosate (Roundup PowerMax). Treatments were applied to three plant species (grain sorghum (*Sorghum bicolor)*, velvetleaf (*Abutilon theophrasti*) and common lambsquarters (*Chenopodium album*)). Nozzles used were TJ60-8002E (fine), DG9502E (fine) and AI9502E (very coarse), each at 414 kpa, 7.7 kph, 94 l/ha and a glyphosate rate of 1.26 kg ae/ha. Treatments were applied to 15 to 25 cm tall plants and rainfall simulated using a HF12015 nozzle in the spray chamber. Rainfall rates of 0.5 and 1.0 cm were applied at time intervals of 0, 1, 3, 5, 15, 30 and 60 minutes after application, as well as a non rainfall treatment. The glyphosate label says to avoid making applications shortly before heavy rainfall applications and 30 minute warrantees have been promoted. Our study showed that the results can vary by species, but having no rainfall event falling the application was clearly the best for maximizing control with glyphosate.

DROPLET SIZE DISTRIBUTION PRODUCED BY CP NOZZLES FOR AERIAL APPLICATIONS OF GLYPHOSATE USING DIFFERENT PRESSURES AND DEFLECTION ANGLES. Guilherme Sousa Alves*[1], Fernando Kassis Carvalho[1], Bruno Canella Vieira[1], Joao Paulo A.R. da Cunha[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Federal University of Uberlandia, Uberlandia, Brazil (40)

There are many factors which effect droplet formation in aerial applications, yet few studies have been conducted for pressure and deflection angles. In addition, glyphosate applications have increased concomitantly with the widespread adoption of glyphosate-resistant crops. The objective of this study was to determine the influence of pressure and deflection angle on droplet size distribution in aerial applications of glyphosate. A completely randomized design study with three repetitions was done in a four by four factorial scheme, being four pressures (103; 207; 310; 414 kPa) and four deflection angles of the CP11TT 8008 nozzle (0º; 30º; 60º; 90º). Roundup PowerMax® was used as the source of glyphosate at rate of 2.34 L ha^{-1} (1.26 g equivalent acid of glyphosate ha^{-1}). The spray concentration was prepared simulating an application at 30 L ha^{-1}. Wind speed was held constant at 190 km h^{-1} by using a high speed wind tunnel with 30 x 30 cm section. The droplet size spectrum for each treatment was collected by a Sympatec HELOS-VARIO/KR laser diffraction system with the R7 lens. The laser beam was place 0.5 m downwind from the orifice of the nozzle. The characteristics evaluated were volumetric median diameter (VMD) and percentage of droplets smaller than 100 µm (%<100 µm). The results show that there is an interaction between pressure and deflection. At 0º deflection, when the pressure was increased larger droplets were observed. The opposite was noticed at 60º and 90º deflection. Linear models were adjusted to account for the interaction. On the other hand, at 30º deflection theVMD was largest at 241 kPa. When the deflection angle was increased, smaller droplets were produced across all pressures.

DROPLET SIZE DISTRIBUTION COMPARISON BETWEEN NOZZLES USED IN GROUND AND AERIAL APPLICATIONS IN A HIGH-SPEED WIND TUNNEL.

Fernando Kassis Carvalho*[1], Guilherme Sousa Alves[1], Bruno Canella Vieira[1], Ulisses R. Antuniassi[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]FCA-UNESP, Botucatu, Brazil (41)

Spray nozzles are responsible for helping determine the droplet size distribution during aerial and ground applications. There, however, exists a concern if airplanes operate with ground spray nozzles. The objective of this work was evaluate the performance of ground spray nozzles in aerial applications. The experiment was conducted at the PAT Lab in North Platte, NE. The volume median diameter (VMD), relative span (RS) and percentage of droplets less than 100 µm (%<100) were measured in a high-speed wind tunnel coupled with a Sympatec HELOS/KR laser diffraction system. Flat fan CP11TT used for aerial applications and XR nozzles used for ground applications were tested. The CP11TT and XR 8003, 8004 and 8006 nozzles were evaluated at 0 and 45º deflection at 180 km h^{-1} wind speed. The spray solution was composed of glyphosate (Roundup PowerMax) at 7.8% v v^{-1}. The operating pressure was 275 kPa. At 0º the DMV of the XR was lower than for the CP11TT for the 8003 and 8006. The XR8003 and 8006 also had lower %<100 compared with their respective CP11TT. At 45º the DMV for the CP11TT nozzles were lower than the XR nozzles and the %<100 was higher. The RS at 45º was lower for the XR 8004 and 8006 compared to the CP11TT 8004 and 8006, respectively.

WIDE RANGE OF DROPLET SIZE DISTRIBUTIONS FROM NON-VENTURI NOZZLES. Thomas R. Butts*, Annah M. Geyer, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (42)

Pesticide drift is a major concern in agricultural production systems. The first recommendation to reduce pesticide drift is to increase spray droplet size. Several factors play an important role in droplet size determination such as nozzle type, application pressure, and spray solution, although nozzle type has the largest influence on droplet size. Venturi nozzles have become the standard for drift reduction as they incorporate a chamber for air to mix with the spray solution before being emitted from the nozzle tip. However, these nozzles are unusable with certain agricultural application systems such as pulse-width modulation systems. Therefore, non-venturi nozzles proven to provide a wide range of droplet sizes are needed for use in these systems. The objective of our research was to identify the spray droplet size distributions of six non-venturi nozzles for potential future use in pulse-width modulation spray application systems. The study was conducted using the low-speed wind tunnel at the Pesticide Application Technology Lab in North Platte, NE, using a Sympatec HELOS-VARIO/KR laser diffraction system for droplet measurements. Water was sprayed through six nozzles, a Teejet Extended Range Flat Spray Tip (XR11004) and Wilger Combo-Jet Tip-Caps (ER11004, SR11004, MR11004, DR11004, and UR11004) at 276 kPa to determine spray droplet characteristics. Each nozzle was traversed through the laser beam three separate times to measure the entire spray plume providing three repetitions. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test and the Tukey adjustment. The $D_{v0.1}$, $D_{v0.5}$, and $D_{v0.9}$ for the UR11004 were 348, 295, and 254% higher, respectively, compared to the ER11004 or XR11004. Relative span was reduced from 1.3 for the ER11004 or XR11004 to 1.0 for the UR11004, indicating more uniformity to the spray droplet distribution from the larger droplet producing nozzle. Furthermore, the UR11004 reduced the percent of fine droplets (<200 µm) in the spray droplet distribution by 35% compared to the ER11004 or XR11004. These results demonstrate non-venturi nozzles are capable of producing a wide range of droplet size distributions critical for spray applications. As droplet size continues to be a critical component for safe and efficacious pesticide applications, our results show non-venturi nozzles can be a beneficial tool for applicators using pulse-width modulation systems.

CARRIER VOLUME AND NOZZLE TYPE EFFECT ON EFFICIENCY OF TANK-MIXTURES OF GLUFOSINATE AND DICAMBA. Frederico da Silva Guimaraes*, Luis Andre Tobias Cardoso Pinto, Thomas R. Butts, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (43)

Dicamba is a systemic herbicide that causes abnormal growth by affecting cell division in broadleaf weeds. Glufosinate is a glutamine synthetase inhibitor that binds to the glutamate site leading to cell membrane disruption and death of the cell. Because it seems likely that dicamba + glufosinate will be tank-mixed in the future, the objective of this study was to evaluate the weed control of dicamba and glufosinate tank-mixtures with three nozzles and two different carrier volumes. The research was conducted at two sites, one near North Platte, NE and one near Brule, NE. A factorial arrangement of treatments used was in a randomized complete design with three nozzles (TTI110015, AIXR110015 and XR110015) and three solutions (280 g ae ha^{-1} of dicamba with one of three rates of glufosinate: 0, 297 and 594 g ai ha^{-1}). Solutions were sprayed with a carrier volume of either 94 or 187 L ha^{-1}. Visual estimations of injury were recorded 28 days after application. In North Platte, the dominant weed species was tumble pigweed (*Amaranthus albus* L.), while kochia (*Kochia scoparia (L.) Schrad*) was the dominant weed species in Brule. The highest level of kochia control using dicamba alone was observed with the TTI110015 nozzle at 94 L ha^{-1}. When using dicamba and 297 g ai ha^{-1} of glufosinate, the highest level of control was with the AIXR110015 nozzle or the XR110015 using 187 L ha^{-1}. When the plants were sprayed with dicamba and 594 g ai ha^{-1} of glufosinate, no differences in control were observed between nozzle type or carrier volume on kochia, except the nozzle XR110015 at 94 L ha^{-1}, which was the lowest level of control. For the control of tumble pigweed, the treatments sprayed with dicamba alone had less than 50% control. The highest level of control was the treatment sprayed with dicamba and 297 g ai ha^{-1} of glufosinate using the XR110015 nozzle. For dicamba and 594 g ai ha^{-1} of glufosinate, all the nozzles with both carrier volumes had good control of tumble pigweed.

EFFECT OF GLUFOSINATE AND DICAMBA RATES ON CONTROL OF GRASSES AND SMALL SEEDED BROADLEAF WEEDS. Luis Andre Tobias Cardoso Pinto*, Frederico da Silva Guimaraes, Thomas R. Butts, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (44)

Tumble pigweed (*Amaranthus albus* L.*)*, kochia (*Kochia scoparia* L. Schrad.*)*, green foxtail (*Setaria viridis* L. Beauv), witchgrass (*Panicum capillare* L.) and stinkgrass (*Eragrostis cilianensis All. Vign. ex Janchen*) are summer annual weeds native to North America and are problematic weeds in the high plains crops. Many cases of inefficient control on these weeds have been reported. This can be caused by application technique, potential resistance and/or rate used. Understanding how to maximize postemergence herbicide efficacy is important, the objective of this study was to evaluate the control of grasses and small seeded broadleaf weeds to different rates of dicamba and glufosinate. The experiment was conducted in two different fields, near North Platte and Brule, Nebraska, in a randomized complete block design with four replications in a factorial arrangement of treatments. Five rates of dicamba (0, 70, 140, 210 and 280 g ae ha^{-1}) and five rates of glufosinate-ammonium (0, 148, 297, 446 and 594 g ai ha^{-1}). The applications were performed with a CO_2 pressurized backpack sprayer, equipped with six Teejet AIXR110015 nozzles, maintained at the working pressure of 359 kPa, and a carrier volume of 200 L ha^{-1}. Visual estimations of injury were recorded 7, 14 and 28 days after treatment (DAT). The data were analyzed using Tukey's multiple pairwise comparisons with $\alpha = 0.05$. The results showed interaction between the rates of dicamba and glufosinate on the foxtail located in Brule. There were no other interactions between the rates of the herbicides for the other weeds in either field. The best control was observed when the maximum rates of the herbicides were applied together.

THE INFLUENCE OF NOZZLE DESIGN ON GLYPHOSATE PLUS 2,4-D OR DICAMBA EFFICACY ON GLYPHOSATE-RESISTANT WEEDS IN NARROW ROW SOYBEAN. Travis Legleiter*[1], William G. Johnson[1], Bryan Young[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Layfette, IN (45)

Broadcast spray nozzles that contain pre-orifice, turbulence chamber, venturi air induction, or a combination of designs that produce very coarse to ultra coarse droplets will be required on new herbicide resistant-soybean crops. Experiments were conducted in 2014 and 2015 evaluating the influence of the nozzle designs on efficacy of a discriminating dose of glyphosate plus 2,4-D or dicamba applied in soybean on four glyphosate-resistant weeds: Palmer amaranth (*Amaranthus palmeri*), horseweed (*Conyza canadensis*), giant ragweed (*Ambrosia trifida*), and common waterhemp (*Amaranthus rudis*). Spraying System Co. TeeJet brand Air Induction Extended Range, and Turbo TeeJet Induction nozzles representing the low drift nozzle designs as well as an Extended Range and Turbo TeeJet nozzles were evaluated for herbicide efficacy. Applications were made when weeds were 10 to 20 cm in height with an ATV sprayer equipped with 11004 nozzles traveling at 19 km hr^{-1}. Herbicide efficacy was evaluated by recording plant heights and biomass in comparison to an untreated check at 21 d after treatment. Glyphosate plus dicamba applications resulted in equivalent weed height and biomass reductions among all nozzle types. Glyphosate plus 2,4-D applications with the Air Induction Extended Range nozzle resulted in less biomass reduction of horseweed in comparison to the Turbo TeeJet Induction nozzle in 2015, although the biomass reduction was similar to the two traditional flat fan nozzles. All other applications of glyphosate plus 2,4-D resulted in equivalent biomass and height reduction across nozzle types. This study reinforces the utility of nozzles containing pre-orifice, turbulence chamber, and air induction designs for effective post-emergence applications of glyphosate plus 2,4-D or dicamba to troublesome glyphosate-resistant weeds in Indiana.

INFLUENCE OF SPRAY WATER PH, FOLIAR FERTILIZERS, AND AMMONIUM SULFATE ON EFFICACY OF A 2,4-D PLUS GLYPHOSATE FORMULATION. Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (46)

Carrier water pH is a critical factor for optimum herbicide efficacy. Foliar fertilizers are often co-applied with POST herbicides which could influence herbicide efficacy. Field and greenhouse studies were conducted to evaluate the effect of carrier water pH, foliar fertilizer, and ammonium sulfate (AMS) on pre-mixtures of 2,4-D plus glyphosate efficacy on horseweed and Palmer amaranth. In the field study, treatments consisted of two factor combinations: carrier water pH (at 4, 6.5, or 9) and foliar fertilizer (zinc or manganese fertilizer at 2.5 or 3.75 L ha^{-1}, respectively). In the greenhouse study, AMS was applied at 0 or 2.5% v/v in addition to the carrier water pH and foliar fertilizer treatments. Pre-mixtures of 2,4-D plus glyphosate was applied at 0.785 and 0.834 kg ae ha^{-1}; and 0.266 plus 0.283 kg ae ha^{-1} in field and greenhouse studies, respectively. In the field study, horseweed control and plant density reduction was 11% or greater with 2,4-D plus glyphosate applied at water pH 4 compared to 6.5 or 9 at four WAT in 2014. Horseweed control and plant density reduction was reduced with 2,4-D plus glyphosate co-applied with Mn compared to Zn fertilizer in 2015. In the greenhouse study, effect of carrier water pH, foliar fertilizer, or AMS was significant for horseweed and Palmer amaranth control with 2,4-D plus glyphosate. pre-mixtures of 2,4-D plus glyphosate showed 7% or greater control of horseweed and Palmer amaranth with carrier water pH 4 compared to 9. Co-applied Mn fertilizer reduced horseweed or Palmer amaranth control compared to without fertilizer. Horseweed or Palmer amaranth control with pre-mixtures of 2,4-D plus glyphosate was increased by 10% with the addition of AMS. In conclusion, 2,4-D plus glyphosate formulation applied with carrier water pH 4 and addition of AMS resulted in greater control of horseweed and Palmer amaranth.

EFFECT OF NOZZLES ON GLYPHOSATE-RESISTANT *AMARANTHUS PALMERI* CONTROL WITH

POSTEMERGENCE HERBICIDES. Matthew C. Geiger*[1], Karla L. Gage[1], Ronald Krausz[2]; [1]Southern Illinois University Carbondale, Carbondale, IL, [2]Southern Illinois University Carbondale, Belleville, IL (47)

Glyphosate-resistant (GR) Palmer amaranth (*Amaranthus palmeri*) is an increasing problem in Illinois. Knowledge of herbicide efficacy and application technology is important for successful control of Palmer amaranth. A field trial was established in Collinsville, IL to study the interactive effects of two nozzle types and two POST herbicide modes-of-action on GR Palmer amaranth control. A growth regulator herbicide (dicamba at 560 g ae/ha + crop oil concentrate (COC) at 1%v/v) and two protoporphyrinogen oxidase (PPO) herbicides (lactofen at 220 g ai/ha + COC at 1% v/v and fomesafen at 395 g ai/ha + COC at 1% v/v), and the combination of each herbicide was applied with a flat fan (XR 8002) and an air induction (TTI 11002) nozzle to 8- to 12-cm GR Palmer amaranth. Visual herbicide efficacy ratings were recorded at 7, 14, 21, and 28 d after application (DAA). Dicamba alone controlled 44 to 53% of the GR Palmer amaranth 28 DAA, regardless of nozzle type. Lactofen alone applied with air induction nozzles controlled only 33% of the GR Palmer amaranth compared to 64% when lactofen was applied with the flat fan nozzles. Nozzle type had no effect on control of GR Palmer amaranth with fomesafen alone with control ranging from 79 to 80% 28 DAA. The addition of dicamba to lactofen or fomesafen increased control of GR Palmer amaranth to 94% or greater 28 DAA, regardless of nozzle type. The results from this trial suggest that the efficacy of lactofen and fomesafen on GR Palmer amaranth may be increased with the addition of dicamba, regardless of nozzle type.

IMPACT OF NOZZLE TYPE AND ADJUVANT ON THE PERFORMANCE OF CLETHODIM ON VOLUNTEER CORN (*ZEA MAYS*). Andjela Obradovic*, Ryan S. Henry, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (48)

Clethodim is an Acetyl CoA Carboxylase (ACCase) inhibitor and is primarily used for postemergence grass control in broadleaf crops. It can be used in mixture with different adjuvants. Adjuvants are used to improve pesticide performance by modifying spray pattern, droplet size, deposition properties, rate of uptake, and/or penetration. Recommended adjuvants for clethodim are non-ionic surfactants (NIS), crop oil concentrates (COC) or ammonium sulfate. The objective of this study was to determine the influence of different adjuvants and spray nozzles on the efficacy of clethodim on volunteer corn (*Zea mays*). Treatments were in a factorial arrangement with five tank solutions, three nozzles and two carrier volumes with a randomized complete block design with eight replications. Clethodim was applied at 25 ae ha^{-1} alone and with COC at 3.33% v v^{-1}, NIS at 0.25% v v^{-1} , Methylated Seed Oil (MSO) at 3.33% v v^{-1}, or High Surfactant Oil Concentrate (HSOC) at 1.67% v v^{-1}. The spray solutions were applied using an XR110015, AIXR110015 or TTI110015 spray nozzle at 276 kPa. Applications were made using single nozzle track sprayer at speeds of 4.1 km h^{-1} and 8.2 km h^{-1} to achieve carrier volumes of 66 and 132 L ha^{-1}, respectively. Visual estimations of injury were collected at 7, 14, 21 and 28 days after treatment. Plants were severed at the soil line, dried for 72 hours at 65˚C, and then dry weights were recorded. The study was conducted in two experimental runs. Results from the study indicated control of the corn was greatest at 66 L ha^{-1} with COC. Nozzle selection did not influence control at this carrier volume. At 132 L ha^{-1}, control was highest using the AIXR nozzle with either MSO or HSOC. The data from this study will be useful to guide applicator decisions when attempting to control grass weeds in a broadleaf cropping systems.

EFFECT OF CLEANOUT METHOD ON THE PERSISTANCE OF AUXINIC HERBICIDE RESIDUE. Kevin R. McGregor*[1], Michael D. Owen[2]; [1]Iowa State University, Ankeny, IA, [2]Iowa State University, Ames, IA (49)

No abstract submitted

2015 NATIONAL WEED CONTEST. Bruce A. Ackley*; The Ohio State University, Columbus, OH (50)

A look back on the 2015 National Weed Contest hosted by The Ohio State University.

DIGITAL BOOK FOR WEED IDENTIFICATION. Bruce A. Ackley*; The Ohio State University, Columbus, OH (51)

Plant identification can be challenging and even intimidating for the inexperienced. Growers do not necessarily need to identify every weed in a field to be effective managers, but should be able to identify the major weeds that are important to their operations and goals. At first glance, learning how to identify weeds can seem like a daunting task given the number and diversity of species, but it is not as difficult as it may seem. Generally, there is a specific group of weeds that tends to dominate disturbed habitats within any native landscape. This iBook, "The Ohio State University Guide to Weed Identification", was created to help people better understand the nature of the weeds they are trying to control, and plant identification is a key component of that understanding. The iBook provides a new way to use an old tool - visualization - in the world of weed identification. Plant descriptions contained herein include key identification characteristics, photos of many species at different stages of maturity, and 360-degree movies for most species in the book. This book is not meant to be a compendium of all weedy plants in the U.S., but rather includes a number of the most common Midwestern U.S. weeds and the basic intellectual tools that are necessary to successfully identify plants.

DISTRIBUTION OF GLYPHOSATE-RESISTANT KOCHIA IN NORTH AMERICA. Phillip W. Stahlman*[1], Ian Heap[2]; [1]Kansas State University, Hays, KS, [2]WeedSmart LLC, Corvallis, OR (52)

Resistance to glyphosate in kochia was first confirmed in 2007, in Kansas. In 2010, 10 widely dispersed kochia populations in the state were confirmed resistant and presence of resistant biotypes in several other populations was suspected but unconfirmed. Resistance levels in the 10 confirmed populations ranged from 3- to 11-fold based on EPSPS gene copy number compared to a susceptible population. EPSPS gene copy number correlated with levels of glyphosate resistance. By the end of 2012, resistance was widespread throughout the central Great Plains and was found and confirmed that year in the northern Great Plains in Montana and North Dakota and in Manitoba and Saskatchewan in Canada. The distribution of glyphosate-resistant kochia continues to expand into additional states and provinces and is complicating weed management in major crop production areas throughout the western USA and Canada.

THE GLOBAL HERBICIDE RESISTANCE ACTION COMMITTEE AUXIN WORKING GROUP - PURPOSE AND PROJECTS. Mark A. Peterson*[1], Arlene Cotie[2], Michael J. Horak[3], Andreas Landes[4], Don Porter[5]; [1]Dow AgroSciences, West Lafayette, IN, [2]Bayer Crop Science, Raleigh, NC, [3]Monsanto, St. Louis, MO, [4]BASF, Limburgerhof, Germany, [5]Syngenta Crop Protection, Raleigh, NC (53)

The Global Herbicide Resistance Action Committee (HRAC) is an Industry organization with representation from 9 major companies working as a part of Crop Life International. HRAC's mission is to maintain the effectiveness and sustainability of herbicides by coordinating and supporting research and communications to prevent and/or delay the onset of weed resistance. Within HRAC there exist several working groups which have been formed to address specific areas of weed resistance management. Working groups often focus on specific mechanisms-of-action (MOA) to develop testing methods, management recommendations, educational efforts, or research programs specific to the MOA of interest. The Auxin Working Group (AWG) was formed in 2013 with the following broad objectives: 1) Review current understanding of the MOA of auxin herbicides in plants; 2) Evaluate public reports of resistance to auxin herbicides; 3) Facilitate research regarding the auxin MOA and mechanisms of auxin resistance in weeds; 4) Contribute to recommendations that will preserve the auxin MOA as an effective weed control tool; and 5) Support the active exchange of information regarding auxin resistance via public conferences, symposia, and publications. Recent projects of the AWG have included a review of auxin herbicide resistance cases listed in the International Survey of Herbicide Resistant Weeds (www.weedscience.org) and development of fact sheets on specific auxin-resistant weed species that can be used as educational tools for a broad audience.

THE PREEMERGENCE MODE-OF-ACTION EXPERIENCE. Joshua Miller*[1], Rodrigo Werle[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (54)

The concept of herbicide resistance management has become familiar to growers and crop consultants in recent years due to increased numbers of resistant weed species and the concurrent absence of new herbicide modes-of-action (MOA). Extension educators must be able to inform consultants and growers on how to properly utilize currently available herbicides to effectively manage weed populations in their fields. A novel herbicide screen design was implemented for the 2015 Mid-Summer Crop Management Diagnostic Clinic at the Agricultural Research and Development Center in Mead, NE to illustrate the effectiveness of different preemergence herbicide MOA when applied individually or together as commercially available premix products. The herbicide screen was conducted using five corn premix herbicides and three soybean premix herbicides. Each premix herbicide was applied at recommended labeled rates along with the individual herbicides that comprised the product at the rates contained therein. Herbicides were applied across rows of eight weed species and eight crop species one d after planting the crops and weeds. Each plot was replicated three times. At 28 d after treatment attendees were guided through the herbicide screen to observe the effectiveness of the different premix herbicides, as well as the action of their individual active ingredients. Attendees were surveyed at the end of the field day to determine how the learning experience was perceived. Forty-eight percent of respondents claimed that the exercise significantly improved their knowledge of the importance of preemergence herbicides on weed control, while 45% claimed the exercise moderately improved their knowledge. Additionally, 66% of respondents said their knowledge about using multiple MOA significantly improved, while 31% said their knowledge moderately improved. The results of the survey supported the idea that the novel design of the herbicide screen would help growers and consultants understand the importance of utilizing multiple preemergence MOA as part of a resistance management program in corn and soybeans.

CORRELATING PHENOTYPE WITH GST EXPRESSION IN ATRAZINE-RESISTANT AND -SENSITIVEÂ *AMARANTHUS TUBERCULATUS*Â SEGREGATING F2 LINES. Sarah O'Brien*[1], Anton F. Evans[1], Janel Huffman[1], Patrick Tranel[2], Rong Ma[1], Kris N. Lambert[1], Dean E. Riechers[1]; [1]University of Illinois Urbana-Champaign, Urbana, IL, [2]University of Illinois, Urbana, IL (55)

Atrazine, a photosystem II inhibitor, is commonly used for selective broadleaf weed control in maize (*Zea mays*) and grain sorghum (*Sorghum bicolor*). Cereal crops such as maize and grain sorghum, as well as some grass weeds such as fall panicum (*Panicum dichotomiflorum*) and wild-proso millet (*Panicum miliaceum*), are naturally tolerant to atrazine due to a high level of glutathione *S*-transferase (GST) activity.

However, due to the widespread use of atrazine, numerous dicot weed species have become resistant to *s*-triazine herbicides. Previous research indicated that two atrazine-resistant populations of tall waterhemp (*Amaranthus tuberculatus*) from Illinois (designated ACR and MCR) possess enhanced GST-mediated detoxification of atrazine that confers whole-plant resistance. One phi-class GST (ArGSTF2) and one tau-class GST (ArGSTU2) were identified in these two populations via proteomic methods, and elevated basal expression levels of *ArGSTF2* in both ACR and MCR populations correlated with atrazine resistance, while expression of *ArGSTU2* was highest in MCR. Using this information, our objective was to conduct a postemergence (POST) atrazine dose-response study in the greenhouse combined with gene expression analyses to test the hypothesis that phenotypes of segregating F_2 lines (derived from a MCR x WCS (atrazine-sensitive) cross) will correlate with constitutive *ArGSTF2* expression levels. Genotypes falling into three distinct categories (RR, Rr, or rr) were tentatively assigned based on their varying phenotypic responses to atrazine POST in the dose-response study. Total RNA was then extracted from F_2 lines representing each genotypic class (determined by dose-response analysis) and *ArGSTF2* expression levels were quantified and compared via qRT-PCR. Results showed that each atrazine-resistant line (RR and Rr) tested displayed high *ArGSTF2* expression levels, ranging from 300- to 3800-fold greater than the low baseline levels detected in atrazine-sensitive lines (rr). As a result, expression of this phi-class *GST* could be used as a marker for screening atrazine-resistant waterhemp populations.

EVALUATION OF CANDIDATE CYTOCHROME P450 EXPRESSION IN MESOTRIONE-RESISTANT, -SENSITIVE AND SEGREGATING F2 WATERHEMP (*AMARANTHUS TUBERCULATUS*) POPULATIONS. Rong Ma*[1], Janel Huffman[1], Aaron G. Hager[2], Patrick Tranel[2], Kris N. Lambert[1], Dean E. Riechers[1]; [1]University of Illinois Urbana-Champaign, Urbana, IL, [2]University of Illinois, Urbana, IL (56)

Waterhemp (*Amaranthus tuberculatus*) is a difficult-to-control annual weed species in agronomic crops, in part due to multiple mechanisms for herbicide resistance. Previous research reported the first case of resistance to 4-hydroxyphenylpyruvate dioxygenase (HPPD)-inhibiting herbicides in a waterhemp population, 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. A similar maize P450 (Nsf1) significantly contributes to multiple-herbicide tolerance in maize, including mesotrione. Our objective was to identify candidate P450 gene(s) for subsequent molecular analyses of mesotrione resistance. Quantitative reverse-transcriptase PCR (qRT-PCR) demonstrated that *ArNsf1*, a waterhemp P450 transcript most similar to maize *Nsf1*, is highly expressed in new leaf and meristem tissue of 10-cm MCR seedlings compared with a HPPD-sensitive population, WCS (from Wayne County, Illinois). *ArNsf1* expression in new leaf and meristem tissue from MCR seedlings harvested at 4, 6, 8, and 10-cm was significantly higher than in WCS seedlings, but not in 2-cm seedlings. Greenhouse and laboratory experiments were conducted to test the hypothesis that higher expression levels of *ArNsf1* correlate with mesotrione resistance in MCR, as well as in two other mesotrione-resistant populations, CHR (Champaign Herbicide Resistant) and NBR (Nebraska HPPD-Resistant). WCS and two additional HPPD-sensitive waterhemp populations were used for comparison with the HPPD-resistant populations mentioned above. *ArNsf1* expression was quantified and mesotrione dose-response analyses (to determine GR_{50} values) were conducted with these populations, as well as in 32 randomly-chosen F_2 lines segregating for mesotrione resistance using vegetatively-cloned plants. qRT-PCR results demonstrated that *ArNsf1* expression is highest in meristem tissue of MCR and CHR seedlings (10 cm) compared with each HPPD-sensitive population at similar heights, but NBR demonstrated an intermediate *ArNsf1* expression level. However, a correlation between GR_{50} values and *ArNsf1* expression was not detected in the segregating F_2 lines. Since mesotrione resistance in MCR is a quantitative trait, *ArNsf1* might be one of several P450s that contribute to mesotrione resistance in HPPD-resistant waterhemp populations, but further molecular-genetic studies are needed to determine if additional P450s and/or other mechanisms may contribute to mesotrione resistance in waterhemp.

MECHANISM(S) OF RESISTANCE TO PS II AND ALS INHIBITORS IN MESOTRIONE RESISTANT PALMER AMARANTH. Sridevi Betha*[1], Curtis R. Thompson[2], Dallas E. Peterson[1], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State, Manhattan, KS (57)

Palmer amaranth has evolved resistance to multiple herbicides with different modes-of-action throughout the US. A population of Palmer amaranth from Seward County, KS was found to be resistant to three herbicide modes-of-action; HPPD-, PS II- and ALS-inhibitors. Previous research from our laboratory showed that the HPPD-inhibitor (mesotrione) resistance in this population is due to rapid metabolism of mesotrione, coupled with increased gene expression of HPPD. The objective of this study was to investigate the mechanisms of resistance to PS II-(atrazine) and ALS- (chlorsulfuron)-inhibitors using a known sensitive Palmer amaranth as control. To determine if mutations in target genes of atrazine (*PsbA*) and chlorsulfuron (*ALS*) contribute towards resistance in this population, these genes were sequenced and analyzed from both resistant and sensitive plants. Interestingly, the most common mutation (Serine 264 Glycine) associated with atrazine resistance in weeds was not found in any resistant plants. Preliminary data suggest that the atrazine resistance is mediated via glutathione S-transferases (GSTs) detoxification. On the other hand, a well-known mutation (Proline 197 Serine) associated with chlorsulfuron resistance was found in 25% of the resistant plants. Nonetheless, ~75% of chlorsulfuron-resistant plants did not show presence of any known mutations in the *ALS* gene, suggesting that these plants may have evolved metabolism-based resistance by P450 monooxygenases. Overall, this population evolved both target-site and non-target site resistances to the above three herbicides. This multiple herbicide-resistant Palmer amaranth, especially, to the important and widely used herbicides poses a serious challenge for weed control and sustainable agriculture.

WHAT IS THE MUTATION RATE FOR HERBICIDE RESISTANCE? Federico Casale*, Patrick Tranel; University of Illinois, Urbana, IL (58)

The high dependence on chemical weed control places herbicide-resistant weeds as a major concern in contemporary agriculture. Like any other evolutionary outcome, a resistant weed population is the result of selection for adaptive alleles. These adaptive alleles can come from the standing genetic variation of the population, immigration from another population, or from *de novo* mutations. The relative contributions of these possible origins of resistance alleles are crucial in the design of resistant-management strategies; however, there is limited empirical data providing such information. The objective of this study is to determine the occurrence rate of *de novo* mutations providing herbicide resistance in a natural plant population. Resistance to ALS-inhibitors in grain amaranth *(Amaranthus hypochondriacus)* is being used as a model system. Seeds were generated from a population sensitive to ALS-inhibitors, and resultant seedlings will be screened with a high-throughput, preemergence-based selection using an imidazolinone herbicide. The experiment was done in a batch-wise process, with a goal to screen about 100 million seedlings. Preliminary results from the first batch are presented.

HPPD RESISTANCE IN WATERHEMP FROM NEBRASKA: EVIDENCE FOR MULTIPLE GENES CONFERRING ENHANCED METABOLISM. Maxwel C. Oliveira*[1], Todd Gaines[2], Amitkumar J. Jhala[1], 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 (59)

Previous results with HPPD-resistant waterhemp population showed that resistance resulted from enhanced mesotrione metabolism. It was also reported that the metabolism-based resistance was inhibited by the cytochrome P450 inhibitor malathion (i.e., malathion synergized mesotrione). However, our field study showed that malathion did not synergized mesotrione. Therefore a greenhouse study was conducted to assess whether metabolism-based resistance may be part of the resistance mechanism in the Nebraska population. Both, the HPPD-resistant and susceptible waterhemp biotypes were treated with three cytochrome P450 inhibitors, including malathion (2000 g ai ha^{-1}), piperonyl butoxide (2000 g ha^{-1}) and amitrole (69 g ha^{-1}). The cytochrome P450 inhibitors were applied three hours prior to application of mesotrione (105 g ha^{-1}), tembotrione (92 g ha^{-1}), and topramezone (24.5 g ha^{-1}) in a factorial design. Based on visual control and biomass reduction, malathion did not synergize mesotrione ($P>0.50$), but synergized with amitrole ($P<0.05$). Tembotrione synergized with all cytochrome P450 inhibitors, malathion ($P<0.01$), piperonyl butoxide ($P<0.01$) and amitrole ($P=0.01$). Topramezone synergized with piperonyl butoxide ($P=0.04$), but not amitrole ($P=0.09$), or malathion ($P=0.17$). In the HPPD-susceptible biotype, treatments provided >95% control and biomass reduction. Results showed that in the HPPD-resistant waterhemp, malathion synergized only tembotrione, piperonyl butoxide synergized tembotrione and topramezone, while amitrole synergized mesotrione and tembotrione. These results provided some evidence that perhaps a multiple genes conferring enhanced metabolism do exist in the HPPD-resistant waterhemp from Nebraska, which warrants further investigation of the subject.

UNRAVELING THE EVOLUTION OF GLYPHOSATE RESISTANCE: DIFFERENT FITNESS COST OF DIFFERENT MECHANISMS. Chenxi Wu*[1], Patrick Tranel[2], Adam S. Davis[3]; [1]University of Illinois at Champaign-Urbana, Urbana, IL, [2]University of Illinois, Urbana, IL, [3]USDA-ARS, Urbana, IL (60)

In a recent fitness study, in which waterhemp (*Amaranthus tuberculatus*) was subjected to six generations of growth in a greenhouse in the absence of herbicide selection, no fitness cost was associated with phenotypic glyphosate resistance. However, glyphosate resistance can be conferred by different resistance mechanisms. For example, both amplification of the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) gene and a mutation within the gene conferring a P106S substitution are known to endow glyphosate resistance independently in many weed species, including waterhemp. The objective of this study was to further examine glyphosate resistance in waterhemp plants generated from the aforementioned fitness study. Both EPSPS alterations (amplification and P106S mutation) were present in the waterhemp population, and the frequencies of these traits were monitored over the six generations using molecular markers. Our results showed that frequency of the mutation for P106S did not decrease over generations, indicating it was not associated with a fitness cost. In contrast, the frequency of plants with EPSPS amplification dropped from 20% to 6.5% and 3% after three and six generations respectively. As a result, the major resistance mechanism of our starting generation shifted from EPSPS amplification (accounting for resistance in 48% of spray survivors in the starting population) to mainly P106S mutation (accounting for resistance in 65% of spray survivors after six generations). In addition, there likely is another glyphosate-resistance mechanism in the population, since several glyphosate-resistant plants possessed neither of the two EPSPS alterations investigated. Results of this study suggest that EPSPS amplification has a fitness cost in the absence of glyphosate selection. Other glyphosate-resistance mechanisms may not have such a cost; potentially limiting the effectiveness of herbicide rotation as an effective strategy for mitigating glyphosate resistance.

DEVELOPMENT OF GLYPHOSATE-RESISTANT *ARABIDOPSIS* LINE TO EXAMINE FITNESS EFFECTS

OF OVER-EXPRESSING EPSPS. Zachery T. Beres*, Lin Jin, Xiao Yang, Jason T. Parrish, Allison A. Snow, David M. Mackey; Ohio State University, Columbus, OH (61)

More than 30 weed species have evolved resistance to glyphosate, and at least five of these species (*Amaranthus palmeri, A. tuberculatus, A. spinosus, Lolium multiflorum,* and *Kochia scoparia*) derive resistance via amplification of the EPSPS gene. Resistant biotypes with gene amplification over-produce EPSPS (5-enolpyruvylshikimate-3-phosphate synthase), which is the target for glyphosate and a key metabolic enzyme of the shikimate pathway. To date, relatively few studies have examined potential fitness effects of over-producing EPSPS in the absence of exposure to glyphosate. To better understand these effects, we developed 9 independent, single-copy, homozygous T3 *Arabidopsis thaliana* lines (Col-0 background) that over-express EPSPS (OX), along with 9 corresponding empty vector lines (EV). *Agrobacterium tumefaciens* strain GV3101 bearing either *35S::EPSPS* or the empty vector (pB2GW7 alone) was used to transform *Arabidopsis* Col-0 by the floral dip method. The T3 OX and EV transgenic lines were compared in two dose response experiments that included wild-type plants. Glyphosate dosages ranged from 0x (control) to 16x (13.44 kg ae ha^{-1}), with three replicates per treatment. Visual scores from 0 (no damage) to 10 (death) were recorded at 7, 14, and 21 d after treatment and were used in regression analyses with the *drc* package in R. In a third experiment, we used 0x vs. 1x glyphosate to compare visual damage and biomass of 20 plants per line three wk after spraying. As expected, these experiments confirmed that the EPSPS over-expression conferred varying levels of resistance to the OX lines, while the EV and wild-type lines remained susceptible to glyphosate. Two OX lines had only weak resistance, possibly due to position effects of transgene insertion. Growth of the remaining OX lines was reduced by 67-86% at 1x when compared to their 0x controls. In contrast, all of the EV and wild-type plants in this experiment died following the 1x treatment. We conclude that over-expression has been achieved in the OX lines based on enhanced resistance to glyphosate. Further studies to compare the growth and reproduction of over-expressed lines with empty vector lines and non-transgenic controls are in progress.

EFFICACY OF FOLIAR APPLICATIONS OF HALAUXIFEN-METHYL COMPARED TO 2,4-D AND DICAMBA ON GLYPHOSATE-RESISTANT HORSEWEED (*CONYZA CANADENSIS*). Cara L. McCauley*[1], Julie M. Young[2], Bryan Young[3]; [1]Purdue University, Lafayette, IN, [2]Purdue University, West Lafayette, IN, [3]Purdue University, West Layfette, IN (62)

Horseweed (*Conyza canadensis*) is a problematic broadleaf weed species in many cropping systems and the auxin herbicides 2,4-D and dicamba are commonly used as components of management strategies. Halauxifen-methyl is a new arylpicolinate auxin herbicide and is currently under development for use prior to planting corn or soybean for management of horseweed and other broadleaf species. Field experiments were conducted at two field sites to investigate the response of horseweed populations to 2,4-D, dicamba, and halauxifen-methyl. Herbicide applications included halauxifen-methyl (2.5, 5, 10 g ae ha^{-1}), dicamba (140, 280, and 560 g ae ha^{-1}), and 2,4-D (280, 560, and 1120 g ae ha^{-1}) which represents an approximate 1/2X, 1X, and 2X of the field use rate for each of the herbicides. In addition, glyphosate at a rate of 870 g ae ha^{-1} was tank-mixed with each of the auxin herbicides at the 1X rate to evaluate any difference in the level or speed of herbicide efficacy on horseweed. Visual estimates of control were recorded at 7, 14, 21, 28, and 56 days after treatment (DAT). Across the different auxin herbicide rates and locations, halauxifen-methyl and dicamba were equally efficacious, achieving greater than 80% control at 28 DAT for the 1X rates when applied to horseweed up to 30 cm in height, while 2,4-D achieved less than 55% control. The addition of glyphosate to the 1X rate of dicamba and halauxifen-methyl had no effect compared to the 1X rate of the auxin herbicide applied alone. However, adding glyphosate to the 1X rate of 2,4-D increased control by 28% at both locations. Both of the horseweed populations were confirmed to be resistant to glyphosate as evidenced by less than 15% control at 28 DAT for glyphosate applied alone at 870 g ae ha^{-1}. These results indicate that halauxifen-methyl has the potential to be utilized in preplant burndown applications to control glyphosate-resistant horseweed with equivalent or greater control than current auxin standards.

INFLUENCE OF ENVIRONMENTAL FACTORS ON THE EFFICACY OF PARAQUAT. Garth W. Duncan*[1], Julie M. Young[2], Bryan Young[3]; [1]Purdue University, Lafayette, IN, [2]Purdue University, West Lafayette, IN, [3]Purdue University, West Layfette, IN (63)

Paraquat can be an effective herbicide for non-selective weed control in preplant and directed herbicide applications. Since the mode-of-action for paraquat is dependent on the activity of photosystem I and environmental factors influence the rate of photosynthesis, the efficacy of paraquat may be diminished under unfavorable environmental conditions such as low light or temperature. Greenhouse experiments were conducted to evaluate the influence of environmental conditions on the efficacy of paraquat on Palmer amaranth, waterhemp, giant ragweed, horseweed, and purple deadnettle. The application factors investigated were adjuvant, application time of day and air temperature. Preliminary research was conducted to determine the rate of paraquat that would result in approximately 50% control for each weed species. Paraquat applied with no adjuvant, nonionic surfactant at 0.25% v/v, or crop oil concentrate at 1% v/v resulted in limited differences in early herbicide symptomology, with the exception of reduced necrosis through 48 HAT on Palmer amaranth when paraquat was applied with crop oil concentrate compared with no adjuvant. The efficacy of paraquat was not influenced by adjuvant on any weed species as determined by plant dry weights at 14 DAT. For the application time of day, plants were sprayed one hour after sunrise, at solar noon, and one hour before sunset in the greenhouse. Application time of day had no effect on the efficacy of paraquat on Palmer amaranth and waterhemp which represent two of the more sensitive weed species to paraquat as determined by previous research. Purple deadnettle, a relatively less sensitive species to paraquat, did exhibit an increase in paraquat efficacy when applied in the morning compared with the latter two application timings. Air temperature did influence paraquat efficacy in some species with horseweed and purple deadnettle control reduced in cooler temperatures (18 C day/13 C night) compared with warmer temperatures (27 C day/16 C night). However, air temperature did not influence paraquat efficacy on the summer annual weeds Palmer amaranth, waterhemp, and giant ragweed. These results suggest that air temperature, and to a lesser extent, time of day can influence paraquat efficacy. However, the specific weed species, and possibly the inherent sensitivity of that species to paraquat, is arguably the most important factor that regulates final paraquat efficacy.

CONTROL OF COMMON LAMBSQUARTERS (*CHENOPODIUM ALBUM*) USING DIFFERENT GLYPHOSATE FORMULATIONS. Milos Zaric*, Ryan S. Henry, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (64)

Common lambsquarters (*Chenopodium album* L.) is a summer annual weed native to Europe and Asia and is recognized throughout the Midwest as one of the most problematic weeds in agriculture. The main challenges for postemergence herbicide efficacy on common lambsquarters is wettability and foliar uptake because of the epicuticular wax on the plant leaves. The cuticle has aldehydes that represent a barrier for water-soluble herbicides. Surfactants may improve efficacy by reducing its surface tension, therefore increasing the wettability and the plant uptake. The objective of this study was to evaluate the efficacy of different glyphosate formulations or different concentrations of nonionic surfactant (NIS) with a glyphosate formulation that does not contain surfactants on common lambsquarters control. Potassium and isopropylamine salt glyphosate formulations associated with different rates of surfactant were sprayed to 30 cm tall common lambsquarters plants at 420 g ae ha^{-1}. The applications were performed using a single nozzle track sprayer calibrated to deliver 94 L ha^{-1} with a AI95015EVS nozzle at 414 kPa. Visual estimations of injury and above ground biomass were recorded 28 d after treatment. Two separate trials were conducted in a randomized complete block design with 11 different glyphosate based treatments: Check, a potassium salt of glyphosate formulation (with no surfactant in the formulation), the same potassium salt of glyphosate formulation + NIS at different rates (0, 0.125, 0. 25, 0.5 and 1 % v v^{-1}), two potassium salt formulations with surfactant, and three isopropylamine salt formulations with surfactant. Each treatment had 10 replications (individual plants) and data were analyzed using analysis of variance. Results indicated that the addition of NIS is necessary for glyphosate efficacy on common lambsquarters. Glyphosate formulations that had NIS had satisfactory control of common lambsquarters. Considering interactions between the herbicide formulation, surfactant and the leaf surface are critical for successful lambsquarters control.

CONTROL OF VOLUNTEER HORSERADISH WITH DICAMBA AND GLYPHOSATE. Matthew E. Jenkins*[1], Ronald F. Krausz[2], Alan Walters[1], Sara M. Allen[3]; [1]Southern Illinois University, Carbondale, IL, [2]Researcher, Belleville, IL, [3]Monsanto Company, Bonnie, IL (65)

Horseradish (*Armoracia* rusticana) is commonly grown in rotation with other agronomic crops. The perennial growth habit of horseradish allows volunteer plants to emerge at high densities in rotational crops. Although volunteer plants do not generally cause yield loss, these plants serve as a host for soil-borne pathogens, which can cause problems in future horseradish crops. Therefore it is important to control volunteer horseradish. Dicamba and glyphosate may be effective options for control of volunteer horseradish. Field studies were conducted in 2014 and 2015 in non-crop area to evaluate the efficacy of early season glyphosate, dicamba and glyphosate plus dicamba applications to simulate a dicamba-tolerant soybean production system. Herbicide rates evaluated were glyphosate at 1,266 (0.5 X) and 1,893 (1X) g ae/ha and dicamba at 280 (0.5X) and 560 (1X) g ae/ha. Herbicides were applied early summer to 10 cm and 20 cm horseradish plants. Eight volunteer horseradish plants were flagged in each experimental unit for data collection. Visual control ratings were conducted at 14, 28, 42, and 56 days after treatment (DAT). At 56 DAT glyphosate alone at the high rate had 83% control of the volunteer horseradish whereas, dicamba alone at the high rate provided 58% control. Glyphosate plus dicamba at the high rate provided 90% control of volunteer horseradish compared to 77% with the low rate of this herbicide combination. These results suggest that, glyphosate plus dicamba at the label rate is an effective option for volunteer horseradish control.

MARKETABILITY EFFECTS FROM SIMULATED GLYPHOSATE DRIFT INJURY TO RED NORLAND POTATO. Amanda Crook*; NDSU, Fargo, ND (66)

Red Norland potato (*Solanum tuberosum* L.) is the most widely cultivated red-skinned variety grown in the U.S. This study was conducted at the NPPGA Research site near Grand Forks, ND in 2014 and 2015 to determine the response in Red Norland potato that were exposed to sub-lethal rates of glyphosate (Gly) drift. Simulation of the glyphosate drift was applied at 1/4, 1/8, 1/16, and 1/32 the standard use rate (840 g a.e. ha^{-1}) during three growth stages: tuber initiation (TI), early tuber bulking (EB) and late tuber bulking (LB). Data was collected on yield, total tuber numbers (TTN), number of damaged tubers (DT), and tubers <56.7 g weight (undesirable size for seed). Foliar damage was only noticeable at the TI stage. Treatments applied at EB and LB did not affect TTN, DT, or tubers <56.7 g. In contrast, Gly applied at 1/16, 1/8, and 1/4 rate to plants at TI resulted in increased TTN. Gly applied at all rates to plants at TI resulted in more DT. More tubers were <56.7 g when plants at TI were treated with 1/8 and 1/4 rate. TI was the most sensitive plant growth stage compared to EB and LB stages.

EVALUATING HERBICIDES FOR USE IN JUNEBERRY (*AMELANCHIER ALNIFOLIA*). Harlene M. Hatterman-Valenti*, Collin Auwarter; North Dakota State University, Fargo, ND (67)

Juneberry has been put into the EPA berry and small fruit group (13-07) and more specifically the bushberry subgroup (13-07B) along with aronia berry, blueberries, currants, and sea buckthorn to name a few. However, this shrub produces small pomes and should be in the EPA pome group (11) with apple, pear, and quince. A number of herbicides have expanded their labels to include apples, but not juneberries. The goal of an effective weed management program is to eliminate weed competition the first six to eight weeks after bud swell and to keep the vegetation-free strip clean through harvest. Herbicide application timing is important to accomplish this goal, especially if winter annuals are present. By evaluating a fall and spring applications, and including glyphosate in the spray application, the research should determine which timing is most effective for perennial weeds that may be present while controlling annuals during the critical weed-free period. Applications of indaziflam + glyphosate, flumioxazin + glyphosate, oxyfluorfen + glyphosate, and rimsulfuron + glyphosate with and without pendimethalin were made early spring, prior to budbreak of 12-year old juneberry. No injury to juneberry was observed. However, grass control, which primarily consisted of quackgrass, was unsatisfactory with all treatments six months after application. In contrast, all treatments provided greater than 85% control of dandelion, perennial sowthistle, and Canada thistle six months after application. The two exceptions were indaziflam + glyphosate and flumioxazin + glyphosate + pendimethalin for perennial sowthistle. Fall applications have been made to the second quarter of the orchard for comparison to the spring applications.

RELATIONSHIPS BETWEEN WEED INCIDENCE, SOIL FERTILITY, AND SOIL PH IN MISSOURI PASTURES. Zach L. Trower*[1], Mandy D. Bish[2], Alex R. Long[1], Meghan E. Biggs[1], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (68)

In Missouri, pastures account for 526,000 hectares of land, and grazing land also occupies about 33% of the total land use in the United States. Weeds are the predominate pest in pastures, costing producers approximately two billion dollars annually. The purpose of this research was to determine if correlations could be found between weed incidence and severity and soil pH and nutrient levels in pasture environments. A total of 26 separate pastures were surveyed in Missouri during 2015. At each pasture site, one 20 m^2 area was surveyed for each four ha within a given pasture. The GPS coordinates of each survey area were recorded, and these areas were re-visited every 14 d between April and October. At each survey area, weed density, height, and stage, and grass and legume forage heights and ground cover were recorded. Soil samples were collected from each survey area to determine soil pH as well as soil phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sulfur (S), zinc (Zn), manganese (Mn), and copper (Cu) levels. Linear regression analyses were conducted in SAS to determine the relationships between weed density and soil pH and nutrient levels. The ten most common weeds found across all 26 pastures surveyed included horsenettle (*Solanum carolinense* L.), common ragweed (*Ambrosia artemisiifolia* L), nutsedge species (*Cyperus* spp. L.), fleabane (*Erigeron annuus* L.), vervain species (*Vervain* spp.*)*, yellow foxtail (*Setaria pumila* P.), honeylocust (*Gleditisia triacanthos* L.), Virginia copperleaf (*Acalypha virginica* L.), dandelion (*Taraxacum officinale* F.H.), and tall ironweed [*Vernonia gigantea* (Walt. Trel.). Annual weeds generally increased throughout the spring and reached their peak density in mid-July, whereas perennial weeds generally increased throughout the spring and early summer and reached their peak density in August. Preliminary results show that for every part per million (ppm) increase of P, K, and Ca, weed density decreased by 1.4, 0.4, and 0.02 plants per 20 m^2 area, respectively. Similarly, for every 1-unit increase in soil pH, weed density decreased by 15.2 plants per 20 m^2 area. This preliminary data indicates that soil pH and nutrient levels have an effect on weed density in pastures, and can be useful to help producers plan comprehensive weed management programs that includes proper maintenance of soil fertility and pH.

RESIDUAL HERBICIDES FOR WEED MANAGEMENT ON MIDWEST RAILROAD RIGHT-OF-WAYS. Matthew R. Terry*, Reid J. Smeda; University of Missouri, Columbia, MO (69)

Weed control along railroad right-of-ways is challenging because of the lack of a crop canopy and the need to control tall growing summer annuals for the entire growing season. Typically, non-selective and higher rates of residual herbicides are applied in early spring, with a follow-up application on emerging species during the summer. Over the past decade, *Amaranthus* species have encroached from agronomic areas and become predominant in industrial areas. Along railroad crossings, two studies were established in spring 2015 (northeast Arkansas and central Illinois) to compare broadcast application of mixtures of traditional and conventional herbicides (six treatments) for control of *Amaranthus* and grass species. No subsequent herbicide application was made. An untreated control (glyphosate + 2,4-D at initial spring application) was used to assess residual herbicide effectiveness. At 28 d after treatment (DAT), Palmer amaranth (AR location) and waterhemp (IL location) control was 92-100%, with the percentage of bare ground (reflects control of all vegetation) ranging from 93-99.5%. Control of annual grasses (large crabgrass and broadleaf signalgrass in AR; large crabgrass and giant foxtail in IL) was 94-100% in AR and 89-97% in IL for five of six treatments. Between 50 and 65 DAT, % bare ground in the untreated control averaged 34-44%, indicating significant weed pressure. Control of Palmer amaranth ranged from 96-100% and for waterhemp ranged from 76-92% for the same five of six treatments. Grass control in AR ranged from 80-100% and in IL ranged from 64-94% for five of six treatments. Evaluations at 85-91 DAT revealed that combinations of rimsulfuron + flumioxazin and prodiamine + flumioxazin resulted in the greatest control of *Amaranthus* species (67.5-84%). Grass control was highest (66-91%) with rimsulfuron + pyroxasulfone + flumioxazin and sulfometuron-methyl + bromacil. Season-long control of *Amaranthus* species and grasses along railroad crossings is best achieved by mixtures of residual herbicides and likely requires sequential application of non-selective compounds.

USING MODELING AND A COMMUNITY-BASED PARTICIPATORY RESEARCH STRATEGY TO STOP THE SPREAD OF PALMER AMARANTH IN IOWA: PRELIMINARY REPORT. Molly Monk*, Maggie Long, Teig Loge, Park Mikels; Simpson College, Indianola, IA

Palmer amaranth, an herbicide-resistant weed, recently began spreading across Iowa. Weed experts say that if left unchecked, Palmer will devastate many sectors of Iowa's economy. An undergraduate research team modeled the spread of the weed over a 21 yr period using NetLogo software. Consultations with local community members and experts in the field helped determine the factors in the model. The model results are an integral part of an awareness campaign targeting a diverse group of stakeholders. The research team will give an overview of their work to date and explain the impact math modeling can have on agricultural decision making.

COMPETITION OF WILD OAT (*AVENA FATUA)* AND WHEAT UNDER FIELD CONDITION. Kulsoom Umm-E*[1], Muhammad A. Khan[1], Amit J. Jhala[2]; [1]University of Agriculture Peshawar, Peshawar, Pakistan, [2]University of Nebraska-Lincoln, Lincoln, NE (70)

Wild oat (*Avena fatua* L.) is an economically important weed in wheat production fields in Pakistan. Interference of wild oat may lead to yield reduction of wheat. The objective of this study was to determine the competitiveness of wild oat with wheat and estimate wheat yield losses at various densities. Field experiments were conducted in 2013 and 2014 at Agricultural Research Station, Chitral, Pakistan to determine the effect of season long interference of wild oat at various densities on wheat yield. The experiment was conducted using an additive design by establishing wild oat densities at 0, 5, 10, 15, 20, 25, 30, 35, and 40 plant m^{-2} in wheat seeded at 125 kg ha^{-1}. Data were collected for several variables including wheat yield and yield attributes. The data analysis was performed in R software using two parameter hyperbolic regression model. The results indicated 50% wheat yield reduction with 119 (± 25) wild oat plants m^{-2}. The number of wheat tillers reduced by 50% at a wild oat density of 1,064 (±280) plants m^{-2}. It is concluded that wild oat is very competitive and if not controlled, it result in significant wheat yield loss depending on density.

WEED COMMUNITY COMPOSITION AND EMERGENCE IN LONG-TERM NO-TILLAGE, STRIP-TILLAGE, AND CHISEL PLOW CORN AND SOYBEAN SYSTEMS. Nathaniel M. Drewitz*, David E. Stoltenberg; University of Wisconsin-Madison, Madison, WI (71)

Strip tillage (ST) is a high-residue, conservation tillage approach that minimizes many of the agronomic risks associated with no-tillage (NT) corn production systems. ST creates a narrow strip for planting in which soil temperature in the planting zone is greater and soil moisture is less than in NT systems, but similar to intensive-tillage systems. The favorable conditions in the tilled strip allow for more timely corn planting, more uniform emergence, and greater early-season growth compared to NT systems. Additionally, the ST system maintains previous crop residue between the strips for soil protection from water and wind erosion, providing an important ecosystem service. However, we have little information on weed management risks in ST corn in the northern Corn Belt. Therefore, our objectives were to characterize weed community composition, emergence patterns, productivity, and suppression in a long-term ST corn/NT soybean rotation compared to an intensive-tillage (chisel plow, CP) continuous corn production system in the Wisconsin Integrated Cropping Systems Trial. The trial is located at the University of Wisconsin-Madison Arlington Agricultural Research Station (43°18'N; 89°21'W) near Arlington, WI on a Plano silt loam (fine-silty, mixed, mesic Typic Argiudolls). The trial was established in 1989 and consists of six cropping systems (including the ST corn/NT soybean rotation and the CP corn system) in a randomized complete block design with four replications. Each cropping system phase is replicated in time as well as in space, such that both phases of the ST corn/NT soybean rotation occur in each year. Plots area is 0.3 ha. Conventional herbicide programs are used for weed management in the ST corn/NT soybean rotation and the CP corn system. The rotation was NT in both corn and soybean phases until 2007, then switched to ST in the corn phase in 2008. In 2015, we found that common lambsquarters was the most abundant species across tillage systems (based on plant density), but rank of other abundant species differed among CP corn (eastern black nightshade, redroot pigweed, dandelion, and yellow foxtail), ST corn (redroot pigweed, dandelion, velvetleaf, and eastern black nightshade), and NT soybean (dandelion, redroot pigweed, shepherd's-purse, and field pennycress). Total weed emergence in non-treated quadrats was greater in CP corn (124 ± 8 plants m^{-2}) than in ST corn (92 ± 16 plants m^{-2}) or NT soybean (56 ± 13 plants m^{-2}). Time to 50% maximum emergence in CP corn (159 ± 18 GDD) did not differ from ST corn (177 ± 46 GDD), but was less than in NT soybean (287 ± 87 GDD). At the time of maximum weed emergence in non-treated quadrats, total weed shoot biomass was much less in ST corn (66 ± 15 g m^{-2}) than in CP corn (154 ± 43 g m^{-2}) or NT soybean (179 ± 35 g m^{-2}). Common lambsquarters accounted for most of the shoot biomass in the each tillage system. In treated quadrats, total weed shoot biomass was very low (<5 g m^{-2}) and did not differ among tillage systems. These results indicate that weed community composition did not differ greatly between long-term intensive- and conservation-tillage systems; however, total weed density and total weed shoot biomass were less in ST corn than CP corn at the time of maximum emergence (canopy closure). These results suggest that long-term cropping system effects have likely contributed to weed community suppression in the ST system and reduced weed management risks and associated crop yield loss potential relative to intensive tillage.

INFLUENCE OF TILLAGE METHODS ON MANAGEMENT OF *AMARANTHUS* SPECIES IN SOYBEAN. Jaime A. Farmer*[1], Vince M. Davis[2], Larry Steckel[3], William G. Johnson[4], Mark Loux[5], Jason Norsworthy[6], Kevin W. Bradley[7]; [1]University of Missouri-Columbia, Columbia, MO, [2]BASF Corporation, Verona, WI, [3]University of Tennessee, Knoxsville, TN, [4]Purdue University, West Lafayette, IN, [5]The Ohio State University, Columbus, OH, [6]University of Arkansas, Fayetteville, AR, [7]University of Missouri, Columbia, MO (72)

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 and 2015 in Arkansas, Illinois, Indiana, Ohio, Tennessee, Wisconsin, and at two sites in Missouri to determine the effects of four tillage treatments combined with one of two herbicide programs 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 of paraquat at 0.84 kg ai/ha at approximately the same time as the spring tillage passes. Each tillage treatment also received one of two herbicide programs; a preemergence (PRE) application of flumioxazin at 0.09 kg ai/ha fb a postemergence (POST) application of glufosinate (0.59 kg ai/ha) plus S-metolachlor (1.39 kg ai/ha), or POST-only applications of glufosinate (0.59 kg ai/ha). 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 quadrats every two wk 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 in 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, and each soil segment was spread as a topsoil layer over three cm deep containers filled with commercial potting medium in the greenhouse. Seedling emergence was monitored over a three month time period. Emerged weed seedlings were counted and identified to species every two weeks, then removed from the pots after counting. Data were subjected to analysis through the PROC GLIMMIX procedure in SAS and means were separated using Fisher's Protected LSD ($P \leq 0.05$). Across tillage types, cumulative *Amaranthus* spp. emergence was at least 70% lower in response to the residual herbicide compared to the POST only herbicide program in 10 out of 14 site-years. Cumulative *Amaranthus* spp. emergence was also 69% lower in deep tillage compared to no-tillage in 10 out of 14 site-years, and conventional tillage reduced *Amaranthus spp.* emergence by 23% compared to no-tillage. Based on soil cores collected following the tillage operations, between 81 and 83% of the total *Amaranthus* spp. seedbank was concentrated in the upper five cm of soil in the no-tillage, conventional and minimum tillage treatments, while only 33% of the total *Amaranthus* spp. seedbank was concentrated in the upper five cm of soil in the deep tillage treatment. The results from this study indicate that combining deep tillage with a two pass herbicide program comprised of a residual PRE herbicide fb a POST treatment was the most effective strategy for the control of *Amaranthus* spp. in these experiments.

SHORTENING PHYSIOLOGICAL DORMANCY OF GIANT RAGWEED SEED ENABLES RAPID GERMINATION FOR RESEARCH. Nick T. Harre*[1], John A. Hettinga[2], Stephen C. Weller[2], Bryan G. Young[2]; [1]Purdue University, West Lafayette, IL, [2]Purdue University, West Lafayette, IN (73)

Whole-plant greenhouse screening for herbicide-resistant weeds is a common practice enabling identification of resistant populations. Information gathered from these screens may then be disseminated by Extension specialists to increase grower awareness regarding the spread and potential threat to crop production systems. Giant ragweed has increasingly become problematic in corn and soybean fields in Indiana as it has evolved resistance to glyphosate and ALS-inhibiting herbicides, thus warranting a rapid and efficient resistance screening process. However, germination of giant ragweed seed is impeded by physical and chemical barriers that must be overcome before germination proceeds. The most common method of breaking innate dormancy in giant ragweed is a lengthy process and is the impetus for this research in which temporal, physical, and chemical variables were investigated to improve germination and circumvent extensive delays in herbicide-resistance testing. Giant ragweed seeds were collected on September 28 (early) and October 28 (late) in 2014. Seeds were immediately tested for germination after undergoing water, chemical, water + clipped, or chemical + clipped treatment. The chemical treatment was comprised of ethephon (3 mM) + gibberellic acid (1 mM) + thiourea (2 mM). The clipped treatment required removal of the "crown" region of the seed by use of a razor blade followed by 48 hr of aeration in an Erlenmeyer flask with either water or chemical solution. Seeds were then evaluated for percent emergence over the next 18 d. The water + clipped treatment for early-collected seeds and chemical + clipped treatment for late-collected seeds each provided similar improvement over the water and chemical treatments alone (> 25% emergence) in initial testing. Following these experiments, seeds were placed in 4 C storage for two mo. During this period, a separate lot of seeds underwent a stratification process whereby they were buried in a moist mixture of 3:1 sand:soil—the current standard for breaking innate dormancy. Emergence was improved following the cold storage period with the water + clipped treatment providing the greatest benefit for both early- and late-collected seeds (> 75%). No other treatment elicited emergence greater than 40%. A larger proportion of late-collected seed emerged compared to early-collected seed when exposed to the water or chemical treatment; however, these differences were eliminated by the soil stratification, water + clipped, or chemical + clipped treatments. Additionally, data were fit to a four-parameter Weibull function and analyses revealed the lag time between planting and emergence was shortest in the water + clipped treatment and the rate at which seedlings emerged over 18 d was fastest. These experiments elucidate a method whereby giant ragweed seed may be propagated for herbicide-resistance testing immediately following collection, thus reducing the time required for confirmation. However, if time warrants, a period of cold storage may be advantageous as this increases the proportion of seeds capable of emerging and may influence the quantity of seed needed to be collected from putatively herbicide-resistant populations.

PHENOLOGY OF FIVE WATERHEMP POPULATIONS GROWN IN A COMMON ENVIRONMENT. Joey M. Heneghan*, William G. Johnson; Purdue University, West Lafayette, IN (74)

Waterhemp (*Amaranthus tuberculatus* var. *rudis*) is a small-seeded broadleaf weed that is present and problematic in agronomic crops across much of the Midwest. Waterhemp is known to exhibit discontinuous germination and generate large amounts of seed. These characteristics can lead to plants of varying sizes to be present in field settings and can also lead to rapid and dense establishment due to high fecundity. A common garden experiment was established in 2014 and 2015 to evaluate the phenology of waterhemp populations from Indiana, Illinois, Missouri, Iowa, and Nebraska. Seeds were germinated in the greenhouse and later transplanted in the field at three different timings to simulate discontinuous germination. The first planting was planted to simulate initial spring emergence, the second and third planting were planted 21 d before and after the summer solstice, respectively. Seedlings were transplanted to the field 12-15 days after greenhouse planting. Weekly height measurements were taken from 12 plants in every plot and end of season biomass accumulation and seed yield was recorded. In 2014 and 2015, combining all populations together, there were no differences between the first and second plantings in biomass accumulation, but the third planting accumulated less. In 2014, there were no differences between the first and second planting in seeds g^{-1}, but there were fewer seeds g^{-1} from the third planting, indicating larger seeds. Within the first and second planting, there were no differences among populations in biomass accumulation. In the third planting, Missouri and Illinois biotypes accumulated the greatest biomass with 338 and 283 g $plant^{-1}$, respectively, while the Iowa biotype accumulated the least with 195 g $plant^{-1}$. Within the first planting, there were no differences among biotypes in seeds g^{-1} with an overall mean of 4860 seeds g^{-1}. In the second and third planting, the Iowa biotype had the fewest seeds g^{-1}, with 4100 and 3370, respectively. The highest total seed production in the first planting was from the Nebraska, Illinois, and Iowa biotypes with 1,255,000, 1,085,000, and 881,300 seeds $plant^{-1}$, respectively. In the second planting, the Iowa biotype produced the greatest number of seeds and the Indiana biotype the fewest with 1,275,000 and 862,000 seeds $plant^{-1}$, respectively. In the third planting, the Missouri and Illinois biotypes produced the greatest number of seeds with 396,000 and 385,000 seeds $plant^{-1}$, respectively, and the Iowa biotype the fewest with 192,000 seeds $plant^{-1}$.

PREVENTING LATE SEASON EMERGENCE OF WATERHEMP (*AMARANTHUS RUDIS*) REDUCES SEED BANK CONTRIBUTIONS. Heidi R. Davis*, Carey F. Page, Reid J. Smeda; University of Missouri, Columbia, MO (75)

Waterhemp is a prolific seed producer; plants emerging in April and July can generate up to 803,400 and 46,600 seeds per plant, respectively. Rapid seed maturation after floral initiation can also contribute to waterhemp fecundity, but little field research has been conducted. In central Missouri, waterhemp seedlings were allowed to germinate in June 2013 and 2014. Plants developed naturally under field conditions with minimal competition by other species. Upon flowering of female plants (stigmas receptive), seed heads were collected from 0 to 42 days. Seed heads were dried at room temperature and seeds were separated and cleaned. A tetrazolium bioassay was developed on sliced seeds to assess seed viability across harvest dates. Viable waterhemp seeds were produced in as few as six d after floral initiation in both 2013 and 2014. Seed viability in 2013 ranged from 1.3 to 50.0% from six to 42 d after floral initiation. In 2014, viability ranged from 5.3 to 74.0% from six to 42 d after floral initiation. For both years, waterhemp viability increased significantly between nine and 12 days after floral initiation; (from 5.3 to 20.0% in 2013 and from 8.0 to 47.3% in 2014), suggesting rapid maturity upon pollination. Seed viability fluctuated throughout the growing season which reflected multiple periods of flowering as new vegetative tissue was generated. Rapid maturity of seeds ensures that late-season emerging plants can contribute viable seeds to the soil seed bank. This suggests full season control of waterhemp is necessary to preclude re-infestation of the soil seed bank.

INFLUENCE OF MULTIPLE HERBICIDE RESISTANCES ON RELATIVE GROWTH RATE AND SEED PRODUCTION IN WATERHEMP (*AMARANTHUS*

TUBERCULATUS). Eric Jones*; Iowa State University, Ames, IA (76)

With heavy reliance on few herbicides to control waterhemp, selection for herbicide resistance has occurred rapidly over the past several years. The objective of this study was to determine if there were differences in relative vegetative growth rate and seed production in comparison of multiple herbicide-resistant waterhemp and herbicide-susceptible waterhemp. Herbicide-resistant waterhemp biotypes included a three-way resistance (glyphosate, atrazine, and ALS-inhibitors), a four-way resistance (glyphosate, atrazine, ALS-inhibitors, and HPPD-inhibitors), and a five-way resistance (glyphosate, atrazine, ALS-inhibitors, HPPD-inhibitors, and PPO-inhibitors). Each of the waterhemp populations was subjucted to a whole plant herbicide screening assay in the greenhouse to confirm the level of herbicide resistance. Male and female plants from the differing population were grown in the greenhouse and placed into the field to grow and reproduce for growth and seed production measurements. Plant heights and number of seeds produced were recorded for each of the plants from the differing populations. From these observations, it can be concluded that multiple herbicide-resistant waterhamp grow and reproduce similarly to herbicide-susceptible waterhemp and do not have a fitness penalty.

SURVEY OF ALTERNATIVE HOSTS AND CULTURAL PRACTICES IN INDIANA FIELDS INFECTED WITH GOSS&RSQUO;S WILT. Taylor M. Campbell*[1], Joseph T. Ikley[2], Kiersten A. Wise[2], William G. Johnson[2]; [1]Purdue University, Lafayette, IN, [2]Purdue University, West Lafayette, IN (77)

Goss's wilt is a bacterial disease in corn caused by *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). Goss's wilt was first discovered in 1969 in Dawson County, Nebraska and today can be found in 17 states and three provinces in Canada. The primary source of inoculum is infected corn debris that serves as an overwintering source for the bacteria. Cultural practices that leave large amounts of residue for bacteria survival are continuous corn production and no-till systems. Pivot irrigation may also aid the bacteria by wounding plants as it moves through the field, splashing the bacteria onto lower portions of the plants, and moving infected debris. Known hosts of Goss's wilt are johnsongrass (*Sorghum halepense*), shattercane (*Sorghum bicolor*), giant foxtail (*Setaria faberi*), green foxtail (*Setaria viridis*), yellow foxtail (*Setaria pumila*), bristly foxtail (*Setaria verticillata*), large crabgrass (*Digitaria sanguinalis*), and annual ryegrass (*Lolium multiflorum*). The objective of this study was to determine if selected cultural practices or alternative weed hosts are commonly associated with the presence of Goss's wilt. Sixteen Indiana fields with a history of Goss's wilt were visited periodically throughout the summers of 2014 and 2015 and were surveyed for cultural practices and weed spectrum. Impact of cultural practices was inconclusive and requires further analysis. The three most commonly observed weeds were giant foxtail, yellow foxtail, and large crabgrass. These weeds were found to have relationship with the presence of Goss's wilt. Though none of the weeds were found to be expressing symptoms of Goss's wilt producers should manage these weeds especially in fields with a history of Goss's wilt, because they are confirmed alternative host and could serve as a "bridge" host to Goss's wilt.

WATERHEMP DENSITY AND BIOMASS AS AFFECTED BY SOYBEAN PLANTING DATE AND REMOVAL TIME OF COVER CROP OR WINTER ANNUAL WEEDS. Kenneth Tryggestad*, Brent S. Heaton, Mark L. Bernards; Western Illinois University, Macomb, IL (78)

No abstract submitted

COVER CROPS: DO THEY REALLY CONTRIBUTE TO THE CONTROL OF PALMER AMARANTH? Douglas J. Spaunhorst*[1], William G. Johnson[2]; [1]Purdue, West Lafayette, IN, [2]Purdue University, West Lafayette, IN (79)

In 2014 and 2015 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 a mixed population of glyphosate-resistant and susceptible Palmer amaranth seed to determine if soybean system, cover crop type, and or herbicide strategy influence Palmer amaranth biomass, density, and soybean grain yield. Prior to the burndown application, annual ryegrass and no cover treatments had 120 and 14, respectively, or more winter and early emerging summer annual weeds than cereal rye cover crop treatments. Burndown treatments which contained flumioxazin reduced Palmer amaranth density 85% or more than burndown treatments without flumioxazin. We also observed that cover crops can inhibit soil residual herbicides on target weeds. For example, in 2014 the cereal rye cover crop plus a burndown treatment mixed with glyphosate plus 2,4-D plus flumioxazin had 8 more Palmer amaranth plants when compared to a burndown treatment mixed with glyphosate plus 2,4-D plus flumioxazin with no cover crop. In both years cover crops did not reduce Palmer amaranth biomass. However, Palmer amaranth biomass was reduced by 98% or more with a burndown treatment of glyphosate plus 2,4-D plus flumioxazin plus a one or two pass post with residual strategy compared to a burndown strategy alone that consisted of glyphosate plus 2,4-D. Moreover, a burndown strategy mixing glyphosate plus 2,4-D resulted in 1,656 and 1,505 kg ha^{-1} less soybean grain yield compared to a burndown strategy of glyphosate plus 2,4-D plus flumioxazin plus a one or two pass post with residual in 2014 and 2015, respectively. Soybean grain yield was similar among cover crop types in 2014. However in 2015, treatments with an annual ryegrass or cereal rye cover crop resulted in 1,174 and 1622 kg ha^{-1}, respectively, more soybean grain yield than treatments without a cover crop. Results from this study suggests that soybean grain yield in response to cover crops are variable between years while herbicide strategy was consistent between years. Soybean system did not impact soybean grain yield and Palmer amaranth biomass. The cereal rye cover crop was more effective than the annual ryegrass cover crop in suppressing winter and early emerging summer annual weeds prior to a burndown application.

EFFECTS OF COVER CROP AND HERBICIDE PROGRAM ON *AMARANTHUS PALMERI* IN NO-TILL SOYBEANS. Chelsea M. Ahlquist*, Dallas Peterson, Anita Dille, Stewart Duncan; Kansas State University, Manhattan, KS (80)

As more weed species evolve herbicide resistance, there is a need to implement multiple strategies for controlling weeds in no-till systems. In 2015, a field study was conducted near Manhattan, KS to determine the effects of cover crops and herbicide programs on the emergence and growth of Palmer amaranth (*Amaranthus palmeri*) in no-till soybeans. Winter wheat was planted November 11, 2014 at 45 kg ha^{-1} in 25 cm rows. Three spring cover crops were planted in 20 cm rows on March 13, 2015 at rates of 74 kg ha^{-1} each for spring oat and spring pea, and in mixture, 49 kg ha^{-1} for spring oat and 25 kg ha^{-1} for spring pea. A no cover treatment was also included. Cover crops were terminated on May 19, 2015 with two different herbicide treatments: 1) glyphosate at 1.1 kg ae ha^{-1} including 1.25% v/v AMS or 2) glyphosate at 1.1 kg ae ha^{-1} including 1.25% v/v AMS, and residual herbicides flumioxazin at 89 g ai ha^{-1} and pyroxasulfone at 112 g ai ha^{-1}. A second application with a tank-mixture of glyphosate at 1.1 kg ha^{-1}, 2,4-D at 1.1 kg ha^{-1}, and 1.25% v/v AMS was applied June 4, 2015 to control spring pea and glyphosate-resistant Palmer amaranth. Glyphosate-resistant soybeans were planted June 10, 2015 at 316,000 seeds ha^{-1}. Another POST application of glyphosate at 1.1 kg ae ha^{-1}, lactofen at 224 g ai ha^{-1}, and 1.25% v/v AMS was applied June 30, 2015 to control Palmer amaranth populations. Cover crop biomass from treatments were different at termination. Winter wheat produced 8260 kg ha^{-1} followed by spring oat, oat/pea mix, and spring pea with least production of 2725 kg ha^{-1}. Spring pea biomass was low due to a poor crop stand. Prior to cover crop termination, Palmer amaranth emergence in spring oat was lowest at 39 plants m^{-2}. Other cover crops reduced emergence compared to no cover treatment where emergence was 221 plants m^{-2}. Palmer amaranth biomass was lowest in oat and wheat compared to other treatments. After cover crop termination, Palmer amaranth escapes were highest in the no cover without residual herbicides (10 plants m^{-2}) and with residual herbicides (one plant m^{-2}) and in the spring pea without residual herbicides (nine plants m^{-2}). At 74 days after termination in treatments without residual herbicides, Palmer amaranth biomass was lowest in winter wheat (7.8 g m^{-2} with one g $plant^{-1}$) and greatest in the no cover treatment (508 g m^{-2} with 55 g $plant^{-1}$). In treatments with residual herbicides, Palmer amaranth biomass was lowest in wheat (0.01 g m^{-2} with <0.01 g $plant^{-1}$) and greatest in pea (18 g m^{-2} with 1.6 g $plant^{-1}$). Total emergence with residual herbicides was lowest in spring oat (68 plants m^{-2}) and highest in wheat (266 plants m^{-2}). Without residual herbicides, total emergence was lowest in pea (226 plants m^{-2}) and greatest in no cover (452 plants m^{-2}) and winter wheat treatments (400 plants m^{-2}). Winter wheat and spring oat cover crops without residual herbicides caused a delay in Palmer amaranth emergence compared to other treatments. Overall, soybean yields were greater in treatments with residual herbicides than with no residual across cover crop treatments. In treatments with residual herbicides, soybean yield was lowest in no cover treatments (2,790 kg ha^{-1}) and greatest in winter wheat cover crop treatments (4,220 kg ha^{-1}). Cover crops such as spring oat and winter wheat may suppress Palmer amaranth emergence and growth when used in combination with residual herbicides such as flumioxazin and pyroxasulfone in no-till soybeans.

HERBICIDE CARRYOVER EVALUATION IN COVER CROPS FOLLOWING WHEAT HERBICIDES. Daniel H. Smith*[1], Vince M. Davis[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]BASF Corporation, Verona, WI (81)

Cover crops are a growing interest for wheat 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 following fall established wheat would affect the subsequent establishment of cover crops in late summer. Wheat trials were established near Sauk City, WI in fall 2013 and Arlington Agricultural Research Station, Arlington, WI in fall 2014. Wheat trials had 14 herbicide treatments applied at common labeled rates and timings. Treatments were replicated four times and a control treatment with no residual herbicide was applied. The wheat was harvested for grain and straw value at the end of July, and seven different cover crop species and/or varieties were seeded uniformly across herbicide treatments. The cover crops included radish (*Raphanus* sp;), crimson clover (*Trifolium incarnatum*), 'Guardian' winter rye (*Secale cereal*), a mixture of 70% oat (*Avena sativa*) plus 30% peas (*Pisum sativum)*, red clover (*Trifolium pretense*), hairy vetch (*Vicia villosa* Roth), and berseem clover (*Trifolium alexandrinum*). Two months after seeding, the cover crops were evaluated for herbicide injury with digital image analysis for percent cover, plant height and stand counts, and by weighing total dried biomass collected from a 0.10 m^2 quadrat. Cover crops did not have reduced stand, height, or percent cover following any of the residual herbicide treatments at $\alpha = 0.1$. From these results, we suggest commonly used wheat herbicides evaluated in this study had little potential to adversely affect the establishment of many different cover crops, although this could be different under drastically different weather, cover crop species, or specific herbicide combinations not examined in this trial. More research will be needed to establish best management practices for farmers interested in the use of cover crops following commonly applied wheat herbicides.

EMERGENCE AND POSTEMERGENCE HERBICIDE RESPONSE OF HORSEWEED (*CONYZA CANADENSIS*) POPULATIONS IN EASTERN KANSAS. Garrison J.

Gundy*, Chelsea M. Ahlquist, Anita Dille; Kansas State University, Manhattan, KS (82)

With the wide adoption of no-till and underutilized use of preemergence applications with residual control, fields across Kansas have developed large populations of horseweed *Conyza canadensis.* These high density populations are forcing producers to use different weed management approaches to prevent substantial impact on yields. The emergence of horseweed in Kansas can occur in the fall or spring creating additional problems in determining optimal timing for control. The objectives for this study were 1) to characterize the emergence pattern of horseweed across eastern Kansas and 2) to compare herbicide sites-of-action for control. Horseweed emergence and survivorship were observed from October 2014 to April 2015 in three locations across eastern Kansas with Highland in the north, Ottawa in middle, and Iola in the south. In the fall greater than 80% of the horseweed emerged in Highland and Iola while 100% emerged in Ottawa. From each of these locations, horseweed plants were transplanted into pots on April 17, 2015 and placed in a greenhouse until time of herbicide application. Horseweed rosettes were grouped by size based on diameter. Herbicides from four different sites-of-action were applied including: EPSP synthase inhibitor (glyphosate, 1262 g ae ha^{-1} + ammonium sulfate at 2% w/v + nonionic surfactant at 25 % v/v), glutamine synthetase inhibitor (glufosinate, 738 g ai ha^{-1} + ammonium sulfate at 3364 g ha^{-1}), T1R1 Auxin Inhibitor (dicamba, 560 g ae ha^{-1}), and ALS-inhibitor (chlorimuron-ethyl, 13.1 g ai ha^{-1} + crop oil concentrate at 1.0% v/v + ammonium sulfate at 2243 g ha^{-1}). Herbicides were applied to four plants in each size group and location using a bench-type sprayer. Individual plants had bolted at time of application, but varied in height from 10 to 20cm. Rosette size was not a factor at the time of glufosinate application resulting in nearly 100% efficacy. Dicamba had much greater efficacy on the smaller bolted rosettes than the larger ones, and glyphosate did not control horseweed plants across all locations. The results of this study highlight the importance of timing of application for horseweed control and utilizing multiple sites-of-action depending on location.

GLYPHOSATE-RESISTANCE AND DISTRIBUTION OF NEBRASKA HORSEWEED (*CONYZA CANADENSIS*) POPULATIONS. Spencer L. Samuelson*, Bruno Canella Vieira, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (83)

Glyphosate-resistant horseweed (*Conyza canadensis (L.) Cronq.*) was first confirmed in Nebraska in 2006 and since then growers have struggled to control horseweed due to continually increasing frequency of resistance and distribution of the resistant biotype. The overall distribution of glyphosate-resistant horseweed populations in Nebraska is currently unknown and unreported. The objective of this study was to find the frequency and distribution of glyphosate-resistant horseweed in the state of Nebraska. A total of 130 horseweed populations were collected arbitrarily from 44 counties (representing the primary row-crop production areas of the state) during the fall of 2013 and 2014. Plants were germinated in a greenhouse in the PAT Lab in North Platte, NE from January to November of 2015. Each population was randomized with seven treatments and at least four replications. Rosettes were treated at 4-5 cm in diameter with the following rates of glyphosate: 0, 217, 434, 868, 1736, 3472, and 6946 g ae/ha using a single nozzle research track sprayer calibrated to deliver 94 L/ha at 414 kPa with a AI9502EVS nozzle. Visual estimations of injury were recorded based on a 0-100 scale (0 being no effect from herbicide and 100 being complete control) at 28 d after treatment (DAT). At 28 DAT, plants were severed at the base and dried at 65°C for 72 hr and dry weight of each plant was recorded for dose response analysis. Data were fitted to a non-linear regression model using the drc package in R 3.1.1. The I_{50}, I_{90}, GR_{50}, and GR_{90} values were estimated for each population using a four parameter log logistic equation: y=c+(d-c/1+exp(b(logx-loge))). A majority of the 130 populations screened showed some level or frequency of glyphosate-resistance. Because of high frequency of the glyphosate-resistant horseweed biotype in Nebraska, growers are encouraged to adopt control methods and techniques that are recommended for the control of glyphosate-resistant horseweed.

RESPONSE OF *AMARANTHUS RETROFLEXUS* POPULATIONS FROM WESTERN NEBRASKA TO GLYPHOSATE. Matthew R. Nelson*, Bruno Canella Vieira, Spencer L. Samuelson, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (84)

Redroot pigweed (*Amaranthus retroflexus* L.) is a member of the Amaranthaceae family, which are known for their rapid growth, prolific seed production, and high level of competition for resources with agronomic crops. Control of redroot pigweed postemergence is difficult because of its adaptability to different environmental conditions, genetic variation and phenotypic plasticity within its species. Redroot, like many other Amaranth species, has shown a propensity to evolve herbicide resistance, and other species in this family have been reported resistant to ALS-inhibiting and photosystem II-inhibiting herbicides in 18 states. Interspecific hybridization has been shown to transfer glyphosate resistance between members of the Amaranthus genus as well. The possibility of redroot pigweed evolving resistance to glyphosate would pose even more challenges for an already difficult to control weed. The objective of this study was to document the variability of redroot pigweed populations from western Nebraska to glyphosate. Redroot pigweed populations were collected from 23 locations throughout western Nebraska and were subjected to a glyphosate-dose response study. Plants were sprayed at 10 cm tall with 0, 39, 217, 434, 868, 1736, 3472 or 6946 g ae ha^{-1} of glyphosate. Visual estimations of injury (0-100%) were recorded 21 d 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.

No glyphosate-resistant redroot pigweed populations were observed in the samples collected from western Nebraska**.** Though resistance was not found, prudent management strategies are necessary to mitigate the future evolution of glyphosate-resistant redroot pigweed.

DISTRIBUTION OF GLYPHOSATE-RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*) IN WESTERN NEBRASKA. Bruno Canella Vieira*, Spencer L. Samuelson, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (85)

Palmer amaranth (*Amaranthus palmeri S. Wats.*) is an annual, C4 and dioecious weed in the Amaranthaceae family that is native to North America. Yield losses up to 79% have been reported in soybeans (Bensch et al. 2003) and up to 91% in corn (Massinga et al. 2001). Due to its dioecious reproduction that confers a high genetic plasticity, this species has a special ability to evolve herbicide-resistance and survive in a wide range of environmental conditions. Several Palmer amaranth populations have been reported resistant to ALS-inhibitors, microtubule assembly-inhibitors, photosystem II-inhibitors, glyphosate, and 4-HPPD-inhibitors in the U.S. The objective of this study was to investigate the susceptibility or resistance of Palmer amaranth populations from Nebraska to glyphosate. Palmer amaranth populations were sampled in Nebraska in 2013 and 2014 and subjected to a glyphosate-dose response study in which different rates of glyphosate (0, 4, 39, 217, 434, 868, 1736 and 3472 g ae ha^{-1}) were applied to 10 cm tall plants using a single nozzle research track sprayer calibrated to deliver 94 L ha^{-1} with a Teejet AI95015EVS nozzle at 414 kPa. Visual estimations of injury and above ground biomass were recorded 21 d after treatment. Data were fitted to a non-linear regression model with the drc package in R 3.1.2. The I_{50}, I_{90}, GR_{50} and GR_{90} values were estimated for each population using a four parameter log logistic equation: y =c+(d –c/1+exp(b (log x –log e))). The results confirm the presence of glyphosate-resistant Palmer amaranth in Nebraska. The distribution and the level of glyphosate-resistance in Palmer amaranth is a key report to ensure a successful integrated weed management of Palmer amaranth in Nebraska.

HERITABILITY OF 4-HYDROXYPHENYLPYRUVATE DIOXYGENASE INHIBITOR HERBICIDE RESISTANCE IN *AMARANTHUS TUBERCULATUS*. Daniel Kohlhase*, Michael D. Owen; Iowa State University, Ames, IA (86)

Since the introduction of herbicides in the 1950's, there has been widespread adoption of herbicides as a leading form of weed management. The reliance on herbicides and lack of diversity in herbicide sites-of-action has resulted in the rapid evolution of resistance. In 2010, two populations of waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer.) were discovered to be resistant to 4-hydroxyphenolpyruvate dioxygenase (HPPD) inhibiting herbicides. Ma et al (2013) described the resistance to be the result of increased herbicide metabolism by cytochrome P450. Little research has been done looking at the genetics of herbicide resistance. The purpose of this research is to determine the inheritance of the HPPD-inhibiting herbicide resistance trait in waterhemp. Reciprocal crosses of HPPD-susceptible and recurrently selected HPPD-resistant waterhemp populations were made. Due to the dioecious nature of waterhemp, the progeny were artificially "selfed" using plants from the same family to obtain pseudo-F_2 seed. The F_1 and F_2 generations were screened in the greenhouse using a range of mesotrione rates and evaluated at three timepoints for percent tissue damage. Initial data analysis shows segregation at the first evaluation timepoint in the F_1 generation at each rate. The F_2 generation shows similar results as the F_1 with a less clear distinction of segregation among the generation. The pattern of a range of tissue damage response across generations, rather than distinct classes, leads us to suspect the resistance trait to be polygenic. More analysis is being done to better describe and attempt to model the response to HPPD herbicides.

POLLEN-MEDIATED GENE FLOW FROM GLYPHOSATE-RESISTANT TO SUSCEPTIBLE GIANT RAGWEED (*AMBROSIA TRIFIDA*) UNDER FIELD CONDITIONS. Zahoor A. Ganie*[1], John L. Lindquist[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska- Lincoln, Lincoln, NE (87)

Giant ragweed is a highly competitive broadleaf weed in agronomic crops including corn, soybean and cotton causing huge yield losses. Glyphosate-resistance in giant ragweed has reduced the control options for this weed in several states of the US and Canada, however, limited literature is available on the dispersal of glyphosate-resistance in giant ragweed via pollen movement. Giant ragweed is a monoecious species showing considerable outcrossing mainly due to its potential for prolific pollen production (>10 million pollen grains per day during the peak flowering period) and anemophily. Therefore, characterization of pollen mediated transfer of resistance from glyphosate-resistant to susceptible giant ragweed populations is required. We hypothesized that distance and direction will influence the pollen mediated gene flow between the glyphosate-resistant and susceptible populations. Field experiments were conducted at Clay Center, Nebraska in 2014 and 2015 using a modified Nelder wheel design with a round center (glyphosate-resistant giant ragweed as a pollen source) (10 m diameter; 80 sq m area) surrounded by pollen receptor (glyphosate-susceptible giant ragweed) area divided into eight directions (four cardinal directions i.e. N, S, E, and W; and four ordinal directions i.e. NE, NW, SE, and SW). Confirmed glyphosate-resistant giant ragweed plants were transplanted in the center and known glyphosate-susceptible giant ragweed plants were transplanted in six m rows starting from 0.5 m to 35 m (0.5, 4, 10, 15, 25 and 35 m) in cardinal directions and up to 50 m (0.5, 4, 10, 15, 25, 35 and 50 m) in ordinal directions. Data for flowering synchrony between source and receptor plants and hourly weather parameters were recorded throughout the duration of field experiments. Seeds were harvested separately for each distance in all the directions from the susceptible pollen receptor plants. After processing, seeds were kept at -4 C for four months to break seed dormancy. The seeds were then planted in greenhouse and screened with 2 (= 1,260 g ai ha^{-1})

rate of glyphosate using glyphosate-resistance as a selectable marker. The results indicated that the proportion of glyphosate-resistant progeny followed an exponential decay model when regressed over increasing distances from the source. Frequency of gene flow was highest near the pollen source (0.38 to 0.54 at 0.5 m) and averaged between 0.1 to 0.17 at 50 m from the source. Average pollen mediated gene flow decreased by 50% and 90% at 19 to 37 m and 63 to 122 m from the source, respectively. The model parameters varied between the directions indicating effect of wind directions on frequency of gene flow. However, more seeds will be screened from the second year of gene flow experiment and results will be compared to determine effect of wind speed, and direction on frequency of gene flow.

CROSS RESISTANCE OF AUXIN HERBICIDES IN A 2,4-D-RESISTANT WATERHEMP POPULATION. Mica Grujic*, Ryan S. Henry, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (88)

Synthetic auxin herbicides, also called growth regulators, mimic hormones in plants. They are foliarly applied and symplastically translocated and they are commonly used to control broadleaf weeds in grass crops, pastures and turf. Waterhemp (*Amaranthus rudis Sauer*) seeds were collected from a native-grass field in Nebraska and screened in 2012 confirming that the population was 2,4-D resistant. As it is the only waterhemp population reported with 2,4-D resistance, it is unknown if the population is resistant to other auxinic herbicides. The objective of this study is to determine if this population is cross resistant to other auxin herbicides. Resistant and susceptible waterhemp populations were treated with seven auxin herbicides and six rates. The herbicides used in this study were 2,4-D (Weedar 64 SL®) at 0, 50, 100, 200, 400 or 800 g ae ha^{-1}, dicamba (Clarity®) at 0, 70, 140, 280, 560 or 1120 g ae ha^{-1}, aminopyralid (Milestone®) at 0, 7, 13, 26, 52 or 105 g ae ha^{-1}, clopyralid (Stinger®) at 0, 13, 26, 52, 105 or 210 g ae ha^{-1}, fluroxypir (Starane®) at 0, 17, 35, 70, 139 or 277 g ae ha^{-1}, picloram (Tordon®) at 0, 35, 70, 140, 280 or 560 g ae ha^{-1} and triclopyr (Garlon®) at 0, 280, 560, 1121, 2242 or 4483 g ae ha^{-1}. The spray solutions were applied using a AI9502EVS nozzle at 414 kPa and 7.8 km h^{-1} to deliver 94 L ha^{-1}. Visual estimations of injury were recorded at 7, 14, 21 and 28 d after treatment (DAT). The plants were severed at the base of the stem and fresh weight was recorded at 28 DAT. Plants were dried for 72 h at 65 C prior to recording dry weights. Control of 2,4-D-resistant waterhemp varied by herbicide and rate. Triclopyr was highly effective at controlling a majority of the waterhemp plants. The population was resistant to 2,4-D and showed cross resistance to clopyralid and potentially triclopyr. There was little or no cross resistance observed in the other herbicides tested.

SIX-YEAR SUMMARY OF MULTIPLE RESISTANCE TESTING IN ILLINOIS POPULATIONS OF WATERHEMP AND PALMER AMARANTH: SO WHAT'S THE GOOD NEWS? Chance W. Riggins*, Aaron G. Hager, Patrick Tranel; University of Illinois, Urbana, IL (89)

In 2009, we initiated a pilot survey to address three basic questions: “How accurate are reports of glyphosate resistance in Illinois waterhemp?”, “How widespread is glyphosate resistance in Illinois waterhemp?”, and “How common is the EPSPS gene amplification mechanism?”. Using DNA-based molecular assays, waterhemp samples were screened for glyphosate resistance (EPSPS amplification mechanism), resistance to ALS-inhibitors (Trp574Leu mutation), and resistance to PPO-inhibitors (G210 deletion mutation). Results from this pilot run suggested the need for expanded sampling and beginning in 2010 samples were acquired by solicitation, mainly from fields where waterhemp was suspected to be resistant to one of these three herbicides. From 2010 to 2015, close to 5000 waterhemp plants from more than 950 fields in 57 counties in Illinois were tested. Evidence from 2010 and 2011 confirmed our expectations that ALS resistance was widespread and present in most fields, and therefore starting in 2012, we opted to only include ALS tests by request and instead focus our efforts on resistance to PPO-inhibitors and glyphosate. Findings by year were consistent in that at least two-thirds of fields tested positive for glyphosate-resistant waterhemp. Furthermore, the data revealed nearly 50% that a glyphosate-resistant waterhemp population also contain PPO-inhibitor resistance. In 2013, our survey protocols were expanded to accommodate escalating interest from growers regarding Palmer amaranth. Suspect Palmer amaranth plants were tested for species identity and, in many cases, multiple herbicide resistance using the same molecular-based assays as used for waterhemp. Based on findings, the range of Palmer amaranth in Illinois was expanded to include 25 new counties, and nearly fifty-percent of plants tested positive for either glyphosate resistance or resistance to ALS-inhibitors. Several populations of Palmer amaranth were also identified as having multiple resistance (ALS + glyphosate). The results of our multi-year survey illustrate the seriousness and prevalence of multiple herbicide resistance, not only in waterhemp populations, but also lurking within the Midwest’s newest invader: Palmer amaranth.

APPLICATION TIMING EFFECTS ON A NOVEL FIVE-WAY RESISTANT POPULATION OF WATERHEMP (*AMARANTHUS TUBERCULATUS*). Cody M. Evans*[1], Patrick Tranel[2], Dean E. Riechers[2], Adam S. Davis[3], Doug Maxwell[1], Lisa Gonzini[1], Aaron G. Hager[2]; [1]University of Illinois, Champaign, IL, [2]University of Illinois, Urbana, IL, [3]USDA-ARS, Urbana, IL (90)

No abstract submitted

EFFECT OF POSTEMERGENCE HERBICIDES ON DISEASE SEVERITY OF GOSS&RSQUO;S WILT IN CORN. Joseph T. Ikley*, Kiersten A. Wise, William G. Johnson; Purdue University, West Lafayette, IN (91)

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 since reemerging, Goss's wilt has been identified in 17 states in the Midwest. Among corn diseases, Goss's wilt is currently the third-leading cause of yield loss in the US and Canada, with an estimated loss of 7 million metric tons in 2013. The cause of the reemergence and spread of the disease is unknown, but has been attributed to an increase in hectacres planted corn-on-corn, an increase in no-tillage practices, and wide-spread use of corn hybrids that are susceptible to Cmn. Other claims have been made that increased use of glyphosate in Roundup-Ready corn has led to an increase in Goss's wilt incidence. In 2013 and 2014, a field experiment was established at the Agronomy Center for Research and Education near West Lafayette, Indiana to determine if choice of POST herbicide affected Goss's wilt severity when compared to corn that was not exposed to POST herbicides. Six-row wide plots were established with the middle two rows containing a Cmn-susceptible corn hybrid and the outer four rows containing a Cmn-resistant hybrid. Only the middle two rows were inoculated with Cmn and the outer four rows served as borders to prevent the bacteria from spreading between plots. The Cmn-susceptible corn hybrid was inoculated at V4 with a bacterial suspension containing 1 x 10^6 colony-forming units (CFU) per mL. At the V6 growth stage, disease severity was measured on 10 plants per plot, then single mode-of-action POST herbicides were sprayed. Disease severity was measured on the same 10 plants per plot every two wk until crop maturity. After POST application, plots were kept weed free until crop maturity and grain yield was collected. Data were analyzed using Dunnett's Test against the nontreated, weed-free control. Disease did not develop in 2014 during severe rainfall and flooding events after inoculation. Results from 2013 reveal that choice of POST herbicide did not affect disease severity nor did it affect crop yield.

KOCHIA RESPONSE TO PRE AND POST APPLIED DICAMBA. Junjun Ou*[1], Curtis R. Thompson[2], Mithila Jugulam[1], Philip W. Stahlman[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State, Manhattan, KS, [3]Kansas State University, Hays, KS (92)

Kochia (*Kochia scoparia*) is one of the most troublesome weeds throughout the North American Great Plains. POST application of dicamba is a viable option to selectively control broadleaf weeds including kochia. However, the recent evolution and spread of dicamba resistance in kochia populations across the Great Plains is a major problem for sustainable crop production. Dicamba is not currently labeled as PRE herbicide to manage kochia. The objective of this research is to assess if PRE treatment of dicamba could be an alternative tactic to manage dicamba-resistant (R) kochia. Experiments were conducted using dicamba-susceptible (S) and R kochia seed under greenhouse conditions. PRE treatments of dicamba at 210, 280, 350, 420 g ae/ha were applied immediately after planting the seeds. A POST treatment of dicamba at the field recommended dose (560 g ae/ha) was applied 4 wk after planting (WAP). Three replicates were included in each treatment, and experiments were repeated. Eight WAP, plant count and dry biomass were collected. The results suggest that the R and S kochia can be controlled over 95% by PRE applied dicamba at 350 and 280 g ae/ha, respectively. In contrast, the R and S kochia were controlled only 10% and 85%, respectively, when dicamba was POST applied at 560 g ae/ha. These results indicate that dicamba could be considered for PRE application to manage R kochia, even at lower than the field recommended dose as POST application. PRE application of dicamba can be a feasible option to manage kochia in rangeland or crop fields and, more importantly, to minimize the spread of R plants.

HOW THE NORTH CENTRAL WEED CONTROL CONFERENCE SHAPED AGRICULTURAL AVIATION IN THE GRASSLANDS. David D. Vail*; Kansas State University, Manhattan, KS (94)

My keynote briefly examines the historical evolution of weed science and custom chemical application in the Great Plains from 1945 to 1985. I will primarily explore the role of the North Central Weed Control Conference and its local relationships with farmers, aerial sprayers, and state policymakers in the central Great Plains. The NCWCC blended expert knowledge, agricultural professionalism, and a local understanding of crop needs and farmer concerns. Studying the ecological relationships between noxious plants, crops, and agricultural chemicals also expanded the scope and breadth of aerial application. Weed scientists helped formalize the standards landowners, pilots, and agriculturalists would hold regarding toxicity and risk when spraying their fields. As the politics of environmental health changed in the aftermath of Rachel Carson's *Silent Spring*, the study of noxious plants encouraged a vision of agricultural health that required poisons for protection.

COMPARISONS OF WINTER VERSUS EARLY SPRING PREEMERGENCE HERBICIDE APPLICATIONS FOR KOCHIA CONTROL IN FALLOW. Randall S. Currie*[1], Patrick Geier[2], Curtis R. Thompson[3]; [1]Kansas State Univ., Garden City, KS, [2]Kansas State, Garden city, KS, [3]Kansas State, Manhattan, KS (97)

With the advent of glyphosate-resistant kochia, preemergence applications of dicamba in early spring have become standard practice. Cold and wet conditions often make it difficult to implement this method of control. Weather patterns often allow a mid-winter application when the work load of applicators is light. Therefore, it was the objective of this research to compare various tank-mixtures with multiple modes of action known to provide excellent spring applied preemergence control of kochia at both winter and early spring timings. A balanced factorial of six herbicide tank-mixtures was applied at two timings. Herbicide treatments are abbreviated by the first letter of the active ingredient of each herbicides in the tank mix and were as follows: DA, dicamba+atrazine at 560+840 g ai/ha; SA, saflufenacil+atrazine at 49+840 g ai/ha; SAD, saflufenacil+atrazine+dicamba at 49+840+280 g ai/ha; PAD, pyroxasulfone+atrazine+dicamba at 146+560+280 g ai/ha;

SIPD, saflufenacil+imazethapyr+pyroxasulfone+dicamba at 25+70+118+280 g ai/ha; or TIAD, thiencarbazone+isoxaflutole+atrazine+dicamba at 21+54+840+280 g ai/ha. These tank-mixtures were applied prior to emergence of kochia during the first week of December or spring (February 3 or March 10, 2015). Control was evaluated 8, 10, 13, 16 and 20 weeks after the spring treatment (WAT). The experiment was conducted near Garden City, and repeated at Tribune, Kansas. Each rating date was analyzed in a three factorial arrangement. All interactions of the six levels of herbicide tank mix, two timings, and two locations were tested. Although all factors interacted at the first rating date by 10 WAT, no three way interactions were significant at the 5% level. Regression of the rate of decline in control over time was conducted for each of the application dates and for each of the herbicide tank-mixtures. Although the three way interactions at the first rating date were significant, control of tank-mixtures averaged over location and herbicide tank mix differed by only 3.8%. These interactions were ignored to facilitate the description of the rate of decay of the subsequent five rating dates which did not have significant three way interactions. At both application timings, the response was very linear with R-squares of 0.92 and 0.95 for spring and winter treatments, respectively. At eight WAT winter applications provided 95% compared to 99% control with the spring applications. At 20 WAT the rate of control of winter applications declined to 60% at a rate of 1.8% per week. In contrast spring applications declined to 754% at a rate of 2.9% per week. The decay in the level of control of individual tank-mixtures ranged from 1.8 to 2.6% per week. Treatment DA declined from 96.3% at eight WAT to 67.5% at 20 WAT at a rate of 2.4% per week. Treatment SA declined from 94.3% at eight WAT to 62.5% at 20 WAT at a rate of 2.6% per week. Treatment SAD declined from 96.3% at eight WAT to 65.5% at 20 WAT at a rate of 2.5% per week. Treatment PAD declined from 98.4 % at eight WAT to 74.3% at 20 WAT at a rate of 1.8% per week. Treatment SIPD declined from 96.4% at eight WAT to 59.6% at 20 WAT at a rate of 2.8% per week. Treatment TIAD declined from 99.2% at eight WAT to 74.4% at 20 WAT at a rate of 2.0% per week. Treatments PAD and TIAD were not significantly different at all rating dates. These treatments provided superior control to all other treatments at 8, 13, or 16 WAT (98, 95, and 89% control, respectively). All treatments provided greater than 94, 90, 86, 78 and 60% kochia control at 8, 10, 13, 16, or 20 WAT, respectively. Depending on the level of control desired at any point within the season, the cost of each treatment, the cost of retreatment and the weed spectrum expected at that time, any of these treatments could be a good value to individual growers. The opportunity cost of the time invested in application in each these seasons will vary greatly for each grower.

PREHARVEST HERBICIDE APPLICATION EFFECTS ON WINTER WHEAT HARVESTABILITY. Kelsey Rogers*, Christy L. Sprague; Michigan State University, East Lansing, MI (98)

Weeds continue to be common in many winter wheat fields at harvest. Late plantings due to delays in previous crop harvesting and earlier winters do not bode well for good establishment of wheat. In addition wetter than normal springs can narrow the window for spring herbicide applications and in some cases prevent them. A field experiment was conducted at the Michigan State University Agronomy Farm in 2015 to evaluate the effect of preharvest herbicide applications on weed desiccation and winter wheat harvestability. Preharvest herbicide treatments included: dicamba, 2,4-D amine, carfentrazone, saflufenacil, glyphosate, and glyphosate in combination with carfentrazone and saflufenacil. Applications were made when wheat was physiologically mature. Treatments were compared to a nontreated control. Common lambsquarters and common ragweed desiccation were evaluated 3, 7, 10 and 15 d after treatment (DAT). Plots were harvested and each plot was assigned a harvestability score and yield was recorded. Samples were collected to measure grain moisture, test weight, percent foreign material, weight of 100 seeds and wheat seed viability. Saflufenacil alone and in combination with glyphosate provided over 85% common ragweed desiccation three DAT. A high level of common ragweed desiccation was also found with glyphosate, however this was not achieved until 15 DAT. Common lambsquarters desiccation required glyphosate and at least 15 DAT. Harvestability scores were also highest with treatments containing glyphosate. These treatments also resulted in the highest test weights, lowest grain moistures and lowest amounts of foreign materials in the harvested crop. Preharvest treatment had little effect on wheat yield. Data from this year's research suggests that of all of the potential preharvest herbicides for use in wheat, glyphosate and glyphosate combinations were the only treatments that resulted in overall effective weed desiccation that improved wheat harvestability and reduced factors that can lead to dockages at the point of sale.

EVALUATION OF HERBICIDE PROGRAMS FOR THE TERMINATION OF EIGHT DIFFERENT COVER CROP SPECIES IN THE SPRING. Cody D. Cornelius*[1], Kevin W. Bradley[2], Mandy D. Bish[3], Alex R. Long[2], Meghan E. Biggs[2], David L. Kleinsorge[4]; [1]University of Missouri, Columbia MO, MO, [2]University of Missouri, Columbia, MO, [3]University of Missouri, 65211, MO, [4]Research Specialist, Columbia, MO (99)

The recent interest in cover crops as a component of Midwest corn and soybean production systems has led to a greater need for research to understand the most effective herbicide program for cover crop termination prior to planting corn or soybean. Previous research has shown that certain cover crop species can reduce subsequent cash crop yields if not properly terminated. A field experiment was conducted in 2013, 2014 and 2015 to determine the most effective herbicide program for the termination of winter wheat, cereal rye, crimson clover, Austrian winter pea, annual ryegrass, hairy vetch and a mix of cereal rye + hairy vetch. Cover crops were planted on September 11, 10, and 12 in 2013, 2014 and 2015, respectively, and herbicide treatments were applied at an early and late termination timing the following spring. Visual control and above-ground biomass reduction was determined 14 and 28 d after application (DAA). Data were subjected to analysis through a PROC GLIMMIX procedure in SAS using Fisher's Protected LSD ($P \leq 0.05$). In general, leguminous species had greater biomass reduction than grass species across herbicide programs relative to the non-treated control. When averaged across herbicide treatments, cereal rye, winter wheat, crimson clover, and Austrian winter pea biomass was reduced by 59, 67, 81, and 84%, respectively. Comparatively, herbicide programs containing paraquat resulted in greater biomass reduction than those containing glyphosate, and glyphosate alone usually resulted in the lowest biomass reduction. Across all cover crop species, paraquat + 2,4-D caused a 78% biomass reduction, which was the greatest among all herbicide programs. Additionally, paraquat + 2,4-D resulted in biomass reductions of 89, 90 and 91% for crimson clover, hairy vetch, and Austrian winter pea, respectively. The early application timing resulted in greater biomass reduction for crimson clover, hairy vetch, cereal rye, and cereal rye + hairy vetch, but not winter wheat, Austrian winter pea, and annual ryegrass. These results show that effective termination of various cover crop species can occur with proper herbicide selection and timely application.

COVER CROP INTERSEEDING IN GRAIN CORN USING A MODIFIED GRAIN DRILL. Daniel H. Smith*[1], Matthew D. Ruark[1], Francisco J. Arriaga[1], Vince M. Davis[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]BASF Corporation, Verona, WI (100)

North Central growers are increasingly interested in utilizing cover crops. While cover crop establishment is relatively easy following corn silage, small grains, and processing vegetables, establishing cover crops successfully following corn or soybean has been more difficult. Aerial seeding or over-the-canopy seeding late in the growing season can be done with moderate success. An alternative approach is to interseed cover crops into a standing corn crop early in the growing season. This management practice requires special, or at least modified, equipment. One benefit may be improved cover crop establishment due to better seed to soil contact and seed placement by using a drill seeder verses broadcasting seed over the soil surface. Ideally, the cover crop will establish prior to canopy closure, but then survive to the end of the growing season without creating excessive competition for resources (nutrients and water) for the corn crop. To investigate this practice, corn trials were established near Arlington, Wisconsin during the 2014 and 2015 growing season. When corn was V5, five cover crop treatments were seeded at university recommended rates on July 14, 2014 and June 24, 2015 using a modified no-till drill. Treatments were replicated four times and a no cover crop control treatment was included. The cover crops included radish (*Raphanus* sp;), 'Guardian' winter rye (*Secale cereal*), a mixture of 70% oat (*Avena sativa*) plus 30% peas (*Pisum sativum*), and red clover (*Trifolium pretense*). The drill was modified by the removal of four row units, which left six row units. This modification allowed the drill to go through the crop rows and plant three rows of cover crops between each corn row. No-till disks and supporting hardware were also removed to prevent damage to the corn. At the same time as corn grain harvest, cover crops were evaluated by weighing the total dried biomass collected from a 0.10 m^2 quadrat in each plot. The oat pea mixture had inconsistent growth in 2015. All other cover crops were successfully established in 2014 and 2015 and had consistent growth during the growing season with good vigor. In 2014 and 2015 the corn never showed any visible symptoms of stress. Cover crops did not reduce corn yields ($p<0.0001$) in 2014. Radish had the most above ground biomass at corn harvest in 2014 with 6274 kg ha^{-1}. Radish and oats peas mixture winterkilled. Winter rye was the only cover crop to need termination in spring 2015. Future research will focus on evaluating the soil conservation, soil carbon building, and potential N credits obtained with interseeding these cover crops.

SULFENTRAZONE TANK-MIX PARTNERS FOR GRASS CONTROL IN ONTARIO DRY BEANS (*PHASEOLUS VULGARIS* L.). Allison N. Taziar*, Peter H. Sikkema, Darren E. Robinson; University of Guelph, Ridgetown, ON (101)

Soil applied herbicides for dry bean (*Phaseolus vulgaris* L.) crops in Ontario are limited. Sulfentrazone is an effective broadleaf herbicide with some grass activity, currently used in some pulse crops in Western Canada. If registered in Ontario, sulfentrazone will provide dry bean growers with another mode-of-action for broadleaf weed control. Twenty-six field studies were conducted over a two-year period (2014, 2015) to determine the tolerance of dry beans to sulfentrazone and to develop weed management programs in white beans with sulfentrazone. Sulfentrazone at 140 and 210 g ai ha^{-1} was mixed with pendimethalin, dimethenamid-p, s-metolachlor or pyroxasulfone. Crop injury was visually assessed at two and four weeks after emergence (WAE). Weed control was evaluated at four and eight weeks after herbicide application (WAA). Weed stand counts and dry weights were taken at eight WAA and yields were determined at maturity. The tank-mixtures evaluated provided good control of large crabgrass (*Digitaria sanguinalis* L.), barnyard grass (*Echinocloa crusgalli* L.), green foxtail (*Setaria viridis* L.) and green pigweed (*Amaranthus powelli* L.), but only sulfentrazone + pendimethalin had an adequate margin of crop safety. Based on this study, although sulfentrazone combined with a grass herbicide provides acceptable control of some grass and broadleaf weed species, further research is required to determine if there is an adequate margin of crop safety for its use for weed management in Ontario dry beans.

HALOSULFURON TANK MIXES APPLIED PPI AND PRE IN WHITE BEAN. Zhenyi Li*[1], Rene Van Acker[1], Darren E. Robinson[2], Nader Soltani[2], Peter H. Sikkema[2]; [1]University of Guelph, Guelph, ON, [2]University of Guelph, Ridgetown, ON (102)

Twelve field experiments were conducted over a two-year period (2013, 2014) to evaluate the tolerance of white bean and spectrum of weeds controlled with halosulfuron applied alone in combination with trifluralin, pendimethalin, EPTC, dimethenamid-p or s-metolachlor applied preplant incorporated (PPI) and pendimethalin, dimethenamid-p or s-metolachlor applied preemergence (PRE). Halosulfuron applied alone or in combination with trifluralin, pendimethalin, EPTC, dimethenamid-p or s-metolachlor caused 3% or less visible injury one and four weeks after emergence (WAE) in PPI and PRE. Halosulfuron applied both PPI and PRE provided greater than 90% control of lambsquarters, wild mustard, redroot pigweed and common ragweed and less than 60% control of green foxtail evaluated four and eight WAE. Weed biomass and density followed a similar pattern. White bean yield with halosulfuron applied in combination with trifluralin, pendimethalin, EPTC, dimethenamid-p or s-metolachlor was equivalent to the weed-free control.

SONIC AND SURESTART II FOR PALMER AMARANTH CONTROL IN AGRONOMIC CROPS. Alinna Umphres-Lopez*[1], Tony W. Weiss[2], Zachary Lopez[3], Thomas C. Mueller[1]; [1]University of Tennessee, Knoxville, TN, [2]Dow AgroSciences, Raleigh, NC, [3]Dow AgroSciences, Bishop, TX (103)

The introduction of glyphosate resistant (GR) crops has allowed producers to have broad-spectrum weed control, reduce tillage practices, and increase the window of herbicide application. Consequently, repeated applications at higher rates coupled with increased selection pressure has resulted in GR weeds. Palmer amaranth (*Amaranthus palmeri*) has become an increasingly troublesome and economically important weed for producers to manage throughout the U.S. Palmer amaranth along with the growing list of resistant weeds, forces producers to incorporate diverse modes-of-action in order to control weeds and prevent the survival of GR weeds. Therefore the purpose of this study was to further evaluate weed control in the southeast with SureStart II and Sonic as a PRE in corn (*Zea mays*) and soybeans (*Glycine max*), respectively. This study was conducted at the University of Tennessee Plant Science Farm-Holston Unit in Knoxville, TN. Plots were arranged in a randomized complete block design with four replications during the 2015 crop season. In corn, treatments consisted of a full rate of SureStart II at 1.5 kg ai ha^{-1} at planting and a split application of 0.9 kg ai ha^{-1} as a PRE and POST. Treatments for soybeans at planting consisted of 147, 221, and 294 g ai ha^{-1}, respectively. Weeds observed in plots were primarily GR-Palmer amaranth followed by pitted morningglory *(Ipomea lacunosa*) and broadleaf signalgrass (*Urochloa platyphylla*). A soybean Liberty-Link system and sequential application of Liberty in-season was utilized. Data were collected on visual assessments of weed control and yield once crops reached maturity. At 30 DAT, weed control in corn showed 96% and 98% control of GR Palmer amaranth for the full and split application of SureStart II, respectively. In soybeans, plots with the 221 and 294 g ai ha^{-1} were observed to have the greatest Palmer amaranth control at 98% and yielded 3,900 and 4,200 kg ha^{-1}, respectively. Data from this study suggests that the use of PRE residual herbicides gives producers the advantage of reducing competition from weeds with longer weed control.

PREPLANT HERBICIDE PROGRAMS UTILIZING HALAUXIFEN-METHYL FOR MANAGEMENT OF GLYPHOSATE-RESISTANT HORSEWEED (*CONYZA CANADENSIS* L.) IN SOYBEAN. Marcelo Zimmer*[1], Bryan Young[2], William G. Johnson[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Layfette, IN (104)

Horseweed was one of the first reported cases of glyphosate-resistant (GR) weeds in the U.S. and is a major issue for production of GR soybeans in the Midwest. Preplant applications of growth regulator herbicides have been effective in controlling horseweed. Halauxifen-methyl is a new growth regulator active ingredient, which has high herbicide efficacy on horseweed and low use rates (5 g ae ha^{-1}). Studies were conducted at four locations in Indiana with GR horseweed to evaluate herbicide programs with halauxifen-methyl in comparison with other existing herbicide programs. Weed control rating, crop injury ratings, weed density counts, soybean crop stand, and yield were assessed. Herbicide programs with halauxifen-methyl provided horseweed control ranging from 90% to 100% control at 35 d after treatment (DAT). Herbicide efficacy of burndown treatments with glyphosate, glufosinate, or 2,4-D only were not consistent across sites, providing horseweed control ranging from 15% to 78% control for glyphosate, 51% to 96% control for glufosinate, and 69% to 83% control for 2,4-D at 35 DAT. Tank-mixtures of glyphosate with residual herbicides improved horseweed control, ranging from 70% to 100% control. Glufosinate tank-mixtures with residual herbicides provided horseweed control ranging from 74% to 99%. Weed density counts provided similar trends to weed control ratings. Overall, no differences were observed for soybean injury, crop stand or yield for any of treatments, other than the nontreated check.

HOW TO IMPROVE THE CONSISTENCY OF GLYPHOSATE-RESISTANT CANADA FLEABANE (CONYZA CANADENSIS L. CRONQ.) CONTROL WITH SAFLUFENACIL: AN INVESTIGATION OF TANK MIX PARTNERS AND OPTIMAL TIME OF DAY APPLICATION. Christopher M. Budd*[1], Peter H. Sikkema[1], Darren E. Robinson[1], David C. Hooker[2], Robert T. Miller[3]; [1]University of Guelph, Ridgetown, ON, [2]University of Guelph\, Ridgetown, ON, [3]BASF Canada, Mississauga, ON (105)

Glyphosate plus saflufenacil, applied preplant, previously provided excellent control of glyphosate-resistant (GR) Canada fleabane in soybean, however, variable control has been observed in recent research and growers' fields. To improve consistency of GR Canada fleabane control, the effect of three-way herbicide tank-mixtures with glyphosate plus saflufenacil, the time of day (TOD) at application, as well as a biologically effective rate of metribuzin with glyphosate plus saflufenacil, were investigated in a two-year study conducted on three farms in Ontario. These sites were previously confirmed with GR Canada fleabane. The TOD treatments were applied at three hr intervals starting at 06 hr to 24 hr and GR Canada fleabane control ratings were completed at 1, 2, 3, 4 and 8 weeks after application for all trials. The 09 hr TOD treatment provided the greatest control with 88%. The best tank mix partners with glyphosate plus saflufenacil were dicamba (300 and 600 g a.i. ha^{-1}), amitrole (2,000 g a.i. ha^{-1}) and metribuzin (400 g a.i. ha^{-1}) which provided 95, 97, 97 and 96% Canada fleabane control, respectively. The addition of 50 and 400 (g a.i. ha^{-1}) of metribuzin was required with glyphosate plus saflufenacil to provide 90 and 95% control, respectively. The TOD appears to have an effect on the control of GR Canada fleabane with glyphosate plus saflufenacil. Metribuzin is an effective tank mix partner to improve the consistency of GR Canada fleabane control. Investigation of variable control with glyphosate plus saflufenacil and ways to improve consistency will provide Ontario growers with a reliable control option.

INVESTIGATIONS OF THE POTENTIAL INTERACTIONS BETWEEN PRE-EMERGENCE RESIDUAL HERBICIDES AND SEED TREATMENTS IN SOYBEAN. Blake R. Barlow*[1], Alex R. Long[1], Meghan E. Biggs[1], Mandy D. Bish[2], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (106)

Earlier planting in combination with the greater adoption of pre-emergent (PRE) residual herbicides has led to an increase in the reported incidences of early-season soybean injury in recent years. During this same time period, the percentage of soybean seed treated with seed treatments has grown substantially. In 2015, a field experiment was conducted to determine if early-season soybean injury correlates with yield loss, and to identify any potential interactions that may exist between herbicides and seed treatments. The experiment was conducted in a randomized complete block design with a factorial arrangement of varieties, seed treatments, and herbicides. Each treatment was replicated five times, and the entire trial was kept weed-free throughout the growing season. Each herbicide and seed treatment combination was evaluated across two soybean varieties of similar genetic background, one with known tolerance to PPO-inhibiting herbicides, and one with known sensitivity to these herbicides. The three seed treatments evaluated include imidacloprid (Gaucho), pasteuria nishizawae (Clariva) plus thiamethoxam (Cruiser), and fluopyram (ILeVO) plus imidacloprid (Gaucho). Each of these seed treatments also contained a common proprietary base treatment blend of insecticides, fungicides, and biologicals. A no seed-treatment control was also included for each variety. Three herbicides were tested across each variety and seed-treatment combination. Chlorimuron-ethyl plus flumioxazin plus metribuzin, chlorimuron-ethyl plus flumioxazin plus pyroxasulfone, and chlorimuron-ethyl plus sulfentrazone were each applied PRE at twice the labeled use rate (2X). A non-treated herbicide control was also included for comparison. Soybean stand counts, height, and biomass measurements were recorded 10 and 30 days after emergence (DAE). Yield data was collected at the end of the season. There was an interaction between variety and herbicide treatment for all of the variables measured except soybean biomass 10 and 30 d after emergence (DAE). The PPO-sensitive variety yielded 13 and 67% lower than the PPO-tolerant variety in response to 2X rates of chlorimuron-ethyl plus flumioxazin plus metribuzin and chlorimuron-ethyl plus sulfentrazone, respectively, but yields were not different between the two varieties in response to chlorimuron-ethyl plus flumioxazin plus pyroxasulfone. Chlorimuron-ethyl plus sulfentrazone was the most injurious to soybean, and this injury manifested itself in the form of stand and height reductions compared to the non-treated control. There were no effects of seed treatments on soybean yield, and very few seed treatment interactions. The only interaction observed between herbicides and seed treatment occurred with stand counts 10 DAE; however by 30 DAE this interaction was not present. The preliminary results from this research indicate that there is not an interaction between the PRE herbicide treatments and seed treatments evaluated in this research, and that early-season stand loss is a greater predictor of yield than either height or biomass reductions. These results also illustrate the need to better understand varietal sensitivity to PPO-inhibiting herbicides.

SOYBEAN YIELDS AND CRITICAL TIME FOR WEED REMOVAL AS INFLUENCED BY SOIL APPLIED HERBICIDES. Maxwel C. Oliveira*[1], Icaro F. Oliveira e Freitas[2], Jon E. Scott[2], Stevan Z. Knezevic[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE (107)

From 2000-2010, the weed control programs in soybeans were based primarily on the POST applications of glyphosate based products, which caused the rapid increase in glyphosate-resistant weeds. Therefore, there is an urgent need for diversifying weed control programs, especially to promote the use of soil applied herbicides with alternative modes-of-action. The objective of our study was to conduct a preliminary study of timing of weed removal that considered use of soil applied herbicides and timing of glyphosate application. The experiment was set up in split-plot design of 14 treatments, two herbicide regimes (No PRE and PRE application of sulfentrazone plus imazethapyr) and seven weed removal times (V1, V3, V6, R2, R5, weed free and weedy season long). Soybean yield was reduced from weed competition in plots without soil applied herbicides. For example, the 5% acceptable yield loss for soybeans started at V1 soybean stage. In contrary, when sulfentrazone plus imazethapyr was applied, the time for weed removal at 5% acceptable yield loss was delayed to V5 soybean stage. Presence of PRE herbicide also reduced overall density of grassy and broadleaves weeds, and helped soybean maintain its height and more uniform stand. Although we consider these results preliminary, as they are based on one year of data, they are clearly showing the benefit of using pre-emergence herbicides for control of early germinating weeds, which are the most competitive against the crop. Control of early germinating weeds also reduced the need for multiple applications of glyphosate, while the use of soil applied herbicides provide an additional mode-of-action for combating glyphosate-resistant weeds.

CONTROL OF GLYPHOSATE-RESISTANT *AMARANTHUS PALMERI* WITH SOIL- AND FOLIAR-APPLIED HERBICIDES IN GLUFOSINATE-RESISTANT SOYBEAN. Kayla N. Wiedau*[1], Ronald F. Krausz[2], Karla L. Gage[3]; [1]Southern Illinois University, Carbondale, IL, [2]Researcher, Belleville, IL, [3]Southern Illinois University Carbondale, Carbondale, IL (108)

Glyphosate-resistant (GR) Palmer amaranth [*Amaranthus palmeri* (S. Wats)] is becoming increasingly prevalent in Midwestern row crop production. Using the most effective herbicide is important for preventing yield loss and limiting further spread of herbicide-resistant weed biotypes; therefore, understanding which herbicide provides the greatest efficacy on Palmer amaranth is critical. The objective of this study is to evaluate soil- and foliar-applied herbicides for weed control and crop safety in a glufosinate-resistant soybean system. Field experiments were established in 2014 and 2015 in Collinsville, Illinois. Thirteen herbicides were used, eight soil-applied and five foliar-applied. The soil-applied herbicides included fluthiacet + pyroxasulfone (150 g ai ha^{-1}), *s*-metoloachlor (142 g ai ha^{-1}), acetachlor (1267 g ai ha^{-1}), pendimethalin (1334 g ai ha^{-1}), pyroxasulfone (149 g ai ha^{-1}), saflufenacil (25 g ai ha^{-1}), sulfentrazone (280, 351, and 420 g ai ha^{-1}), and flumioxazin (71, 90, and 108 g ai ha^{-1}). Foliar-applied herbicides included lactofen (211 g ai ha^{-1}), fomesafen (396 g ai ha^{-1}), fluthiacet (7 g ai ha^{-1}), flumiclorac (61 g ai ha^{-1}), and glufosinate (650 g ai ha^{-1}). Crop injury and weed control ratings were taken at 14, 28 and 56 d after treatment (DAT). PPO-inhibiting herbicides, soil- and foliar-applied, injured crops greatest at 14 DAT. Flumioxazin and sulfentrazone at the highest rates caused 3 to 5% soybean injury 14 DAT in 2014. In 2015, flumioxazin and sulfentrazone at the highest rate caused 10% and 23% soybean injury, respectively, 14 DAT. With the foliar–applied herbicides, lactofen caused the greatest soybean injury (12 to 15%) 14 DAT in both years. Sulfentrazone controlled 90 to 94% of GR Palmer amaranth 56 DAT whereas flumioxazin controlled GR Palmer amaranth 78 to 84% across years. Pyroxasulfone + fluthiacet controlled 94% of GR Palmer amaranth 56 DAT whereas *s*-metolachlor and acetochlor controlled 72% and 33% of GR Palmer amaranth, respectively, across years. Glufosinate controlled GR Palmer amaranth 95% across years. Fomesafen controlled 90% of GR Palmer amaranth compared to 39% control with lactofen across years. Therefore, when considering options for control of GR Palmer amaranth soil-applied herbicides, pyroxasulfone and sulfentrazone, and foliar-applied herbicides, fomesafen and glufosinate effectively control GR Palmer amaranth.

DICAMBA DROPLET RETENTION ON COMMON LAMBSQUARTERS AND SOYBEAN LEAVES AS INFLUENCED BY NOZZLE TYPE, APPLICATION PRESSURE, AND ADJUVANT. Cody F. Creech*[1], Ryan S. Henry[2], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Scottsbluff, NE, [2]University of Nebraska-Lincoln, North Platte, NE (109)

Off-target movement of growth regulator herbicides can cause severe injury to susceptible plants. Apart from not spraying on windy days or with excessive 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 how nozzle types, adjuvants, and pressure impact spray retention on a leaf surface. Common lambsquarters and 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. Three nozzles (XR, AIXR, and TTI) were evaluated at 138, 259, and 379 kPa. Dicamba (0.14 kg ae haâ • »¹) was applied alone and with a non-ionic surfactant (NIS), crop oil (COC), methylated seed oil (MSO), silicone, or drift reduction adjuvant (DRA) and contained 1, 3, 6, 8-pyrene tetra sulfonic acid tetra sodium salt as a tracer. Dicamba spray retention when applied using the XR nozzle, which produced the smallest spray droplets, was 1.75 times greater than when applied with the TTI nozzle which had the largest spray droplets. Applying dicamba with MSO resulted in spray retention on leaf surfaces nearly four times the amount achieved when applying dicamba without an adjuvant. The lowest application pressure (138 kPa) had more than 10% more dicamba spray retention compared to the higher pressures 259 and 379 kPa. By understanding the impacts of these application parameters on dicamba spray droplet retention, applicators can select application parameters, equipment, and adjuvants that will maximize the amount of dicamba spray retained on the target leaf surface while minimizing dicamba spray drift.

SPRAY SOLUTION DEPOSITION AND RETENTION ON GLYPHOSATE-RESISTANT WEEDS IN NARROW ROW SOYBEAN AS INFLUENCED BY SPRAY NOZZLE DESIGN. Travis Legleiter*[1], William G. Johnson[1], Bryan Young[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Layfette, IN (110)

Concern of spray particle drift has prompted the required use of nozzles that produce very coarse to ultra coarse droplets for postemergence herbicide applications associated with the use of new herbicide-resistant soybean traits. Experiments were conducted in Indiana in 2014 and 2015 to evaluate herbicide deposition and coverage on glyphosate-resistant Palmer amaranth, horseweed, giant ragweed, and common waterhemp as influenced by broadcast spray nozzle designs. Glyphosate plus 2,4-D was applied to 10 to 20 cm tall weed species in 38-cm row soybean with two traditional flat fan nozzles: TeeJet brand Extended Range and Turbo TeeJet; and two drift reduction nozzles: Air Induction Extended Range and Turbo TeeJet Induction. 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 Kromekote cards was less with the two air induction nozzles as compared to the Turbo TeeJet and Extended Range nozzles, regardless of weed species. Deposition of spray solution onto the target weed species ranged from 0.2817 to 0.7184 ul/cm^2 , although differences between nozzle types were not significant despite the differences in deposition density observed on the Kromekote cards. The data collected in this research has demonstrated that spray solution deposition onto the target weed surfaces was equivalent across broadcast nozzle types which may translate into similar levels of herbicide efficacy on problematic weed species.

PULSE-WIDTH MODULATION DUTY CYCLE AND APPLICATION PRESSURE EFFECT ON DROPLET SIZE. Thomas R. Butts*, Annah M. Geyer, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (111)

Pulse-width modulation spray application systems allow for variable rate control of flow by pulsing an electronically-actuated solenoid valve placed directly upstream of the nozzle. The flow is changed by controlling the relative proportion of time each solenoid valve is open (duty cycle). This system allows real-time flow rate changes to be made without manipulating application pressure as in other variable rate spray application systems. Application pressure based variable rate flow control devices have been shown to have slow response time and affect nozzle performance, specifically droplet size. The variation in droplet size can negatively impact herbicide efficacy and off-target movement of spray particles. Therefore, the objective of our research was to observe the effect of pulse-width modulation duty cycle and application pressure on droplet size. The study was conducted as a five (application pressure) by six (duty cycle) factorial completely randomized design using the low speed wind tunnel at the Pesticide Application Technology Lab in North Platte, NE, using a Sympatec HELOS-VARIO/KR laser diffraction system for droplet measurements. Water was sprayed through a Wilger Combo-Jet Tip-Cap (MR11004) at application pressures of 138, 207, 276, 345, and 414 kPa and duty cycles of 20, 40, 50, 60, 80, and 100%. Each treatment was traversed through the laser beam three separate times to measure the entire spray plume providing three repetitions. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test and the Tukey adjustment. A significant application pressure by duty cycle interaction (p<0.0001) was identified for the $D_{v0.1}$, $D_{v0.5}$, $D_{v0.9}$, relative span, and percent of fines <200 µm. The mean differences observed from duty cycle were miniscule for the 40 to 100% duty cycles (<30 µm differences in $D_{v0.5}$). The 20% duty cycle was highly variable, causing up to a 93 µm difference in $D_{v0.5}$ values compared the higher duty cycles and increasing percent of fines by up to six percent. Increases of up to 170 µm in the $D_{v0.5}$ and 15% in fine droplets occurred when application pressure was increased by 276 kPa. Our results indicate pulse-width modulation systems should be operated at duty cycle ranges between 40 to 100% to produce similar droplet spectrums. When operated within this range, flow can be variably controlled without the negative impact on spray nozzle performance associated with pressure based changes.

EVALUATION SPRAY PATTERN UNIFORMITY OF GROUND NOZZLES USING LABORATORY AND FIELD TECHNIQUES. Ryan S. Henry*[1], Joe D. Luck[2], Brad K. Fritz[3], W. C. Hoffmann[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]USDA-ARS, College Station, TX (112)

Spray pattern uniformity can impact both efficacy and off-target movement of agrochemicals. The uniformity of agrochemical applications can be influenced by a variety of factors, including nozzle selection, application speed, and the formulation of the tank-mixture. Several nozzle types, application methods, and tank-mixtures common to ground applications in the US were tested for pattern uniformity using two method techniques. A spray patternator equipped with time-based volumetric sensing modules was utilized to measure pattern uniformity for three nozzle types, two tank-mixtures, and variable application heights and nozzle spacing. All treatments resulted in less than ten percent variation across the tested 1.5 meter boom width. A field study utilizing a self-propelled sprayer was also completed. That dataset indicated a nozzle by carrier volume interaction. The current presentation will comment on the latest technologies used for spray pattern uniformity testing, and it has the potential to guide U.S. growers towards more uniform and effective agrochemical applications.

EFFECT OF CARRIER WATER HARDNESS AND AMMONIUM SULFATE ON EFFICACY OF A 2,4-D AND GLYPHOSATE FORMULATION. Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (113)

Spray water quality is an important consideration for optimizing herbicide efficacy. Hard water cations in the carrier water can reduce herbicide performance. Separate greenhouse studies were conducted to evaluate influence of hard water cations and use of ammonium sulfate (AMS) on efficacy of 2,4-D choline, and premixed 2,4-D choline plus glyphosate for giant ragweed, horseweed, and Palmer amaranth control. Carrier water hardness was established at 0, 200, 400, 600, 800, or 1000 ppm, and without or with AMS at 2.5% v/v. 2,4-D choline was applied at 280 g ae ha^{-1} and 2,4-D choline plus glyphosate was applied at 266 plus 283 g ae ha^{-1}, respectively. An increase in carrier water hardness showed a linear trend for reducing 2,4-D choline, and 2,4-D choline plus glyphosate efficacy on all of the weed species evaluated in both studies. The increase in water hardness level reduced giant ragweed control with 2,4-D choline, and premixed 2,4-D choline plus glyphosate at a higher rate in the absence of AMS compared to the addition of AMS in the spray solution. The addition of AMS improved giant ragweed, horseweed, and Palmer amaranth control â‰¥17% and â‰¥10% for 2,4-D choline, and 2,4-D choline plus glyphosate application, respectively. The dry weight reduction of all weed species was â‰¥8% and â‰¥5% with 2,4-D choline, and 2,4-D choline plus glyphosate application, respectively, with the addition of AMS.

EFFECTS OF SPRAY SOLUTIONS ON THE APPLICATION OF ENLIST DUO. Matthew R. Nelson*[1], Ryan S. Henry[1], Jerome J. Schleier III[2], Thomas R. Butts[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Dow AgroSciences, Indianapolis, IN (114)

Enlist Duo™ herbicide, a pre-mixture of 2,4-D choline and glyphosate in a formulation that has low drift characteristics, has been developed for postemergence applications on 2,4-D- and glyphosate-tolerant crops. While the Enlist Duo™ formulation may be a useful tool for managing weeds, it must be used cautiously as off-target movement poses a serious threat to non-target crops. Droplet size classification has a large influence on herbicide drift and increasing droplet size is the easiest management tactics to reduce drift. While the 2,4-D choline formulation has reduced volatility, a very specific label for the Enlist Duo™ herbicide was developed to mitigate drift. The objective of this study is to determine spray droplet size classifications of different forms of glyphosate and 2,4-D in comparison to Enlist Duo™. The experiment consisted of 16 herbicide solutions, including combinations of 2,4-D and glyphosate. The study was conducted in a low-speed wind tunnel at the PAT Lab in North Platte, NE. Droplet size was measured using a SympaTec laser diffraction instrument located 30 cm behind the nozzle and all droplet size measurements were made at 23 km h^{-1}. The selected nozzle for treatments was the AIXR11004 operated at 2.76 bar. The study showed that six out of 16 combinations of glyphosate and 2,4-D resulted in smaller DV_{10} and VMD values when compared to Enlist Duo™, and seven combinations resulted in a higher percentage of driftable fines (< 200 µm). This data shows that the droplet size classification for combinations of glyphosate and 2,4-D differs from that of Enlist Duo™ herbicide, which changes the potential for off-target movement during application. Following label parameters is of great importance as reducing herbicide spray drift is critical for safe application of Enlist Duo™.

WHAT HAVE WE LEARNED AND HOW WILL WE SPRAY IN THE ERA OF HERBICIDE TOLERANT CROPS? Robert E. Wolf*[1], Scott M. Bretthauer[2]; [1]Wolf Consulting & Research LLC, Mahomet, IL, [2]University of Illinois, Urbana, IL (115)

Controlling hard to kill or resistant weed species is an ever growing concern. Many reasons have been identified as contributing to this issue. Glyphosate, a heavily used herbicide, is often discussed as a cause for this problem. Improper application techniques have also been discussed as a contributing factor. A strategy being developed to help control resistant weeds involves the introduction of new herbicide-tolerant crops utilizing a different approach to future crop protection choices. The application strategies accompanying these crops and the associated herbicide recommendations will require increased attention to the application practices. Drift mitigation is an application concern that will be as critical as ever. Multiple field research projects with a laboratory component were conducted in 2010 through 2014 to evaluate the effect of nozzle types, droplet size, and drift reduction adjuvants on weed control efficacy. The studies were planned to determine application strategies to overcome issues related to both efficacy and drift mitigation that have surfaced when spraying hard to kill and resistant weeds. Treatments included tank-mixtures of dicamba, glyphosate, and adjuvants including drift reduction products/deposition aids. The application volume studied was 94 l/ha^{-1}. In 2010 through 2012 multiple weed species were evaluated. In 2013 and 2014 glyphosate-resistant waterhemp control was evaluated using a technologically improved formulation of dicamba. Multiple nozzle types were evaluated in the various studies representing various manufacturers and designs with the focus on nozzle types designed to mitigate drift. Spray applications were made using a customized ATV sprayer adapted with technology to spray the plots ranging from 10 MPH in 2010 to 13 MPH in the remaining years utilizing pressures from 40 to 60 PSI. This allowed the researchers to incorporate commercial application speeds, nozzle sizes, and spray pressures matching probable recommendations for future applications of this type. The nozzle types and tank mix recipes used in each trial were then evaluated in a wind tunnel utilizing laser technology to determine the droplet data and to get an estimate on the drift potential for each. A summary of the findings indicate that nozzle types designed for drift reduction increased the droplet size. Nozzle type alone can be the best choice for drift reduction. Adding a drift reduction product/deposition aid also tended to increase the droplet size and reduced the driftable fines. Typically, there were no differences in weed control efficacy attributed to nozzle type. Efficacy was not reduced with the inclusion of drift reduction products/deposition aids. Though control of resistant waterhemp was not as good as with other weed species in earlier trials, there were no differences found among nozzle and drift reduction product/deposition aid treatments. For all the tested conditions for the 2010 through 2014 studies, we surmise that drift reduction technology can be used to mitigate drift without sacrificing weed control when spraying tank mixtures of dicamba and glyphosate. Application strategies for the future will include using nozzles designed to mitigate drift, will likely include drift reduction product/deposition aids, and are likely to be specific regarding the droplet size, which will dictate pressure and speed for a give nozzle size.

DRIFT CAUSED BY GLYPHOSATE AND 2,4-D AMINE SPRAYED BY DIFFERENT NOZZLES UNDER SEVERAL WIND SPEED CONDITIONS. Guilherme Sousa Alves*[1], Ryan S. Henry[1], Joao Paulo A.R. da Cunha[2], Bruno Canella Vieira[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Federal University of Uberlandia, Uberlandia, Brazil (116)

Glyphosate and 2,4-D are some of the most commonly used herbicides worldwide for weed control which has been a cause of concern due to soil and ground water contamination as well as drift. The objective of this study was to determine the drift caused by glyphosate and 2,4-D amine sprayed with XR, DG and AIXR nozzles under four different wind speeds in a low-speed wind tunnel. The wind speeds used were 0.9, 2.5, 3.6, and 4.9 m s^{-1}. For each wind speed, a completely randomized design study with four repetitions was used in a 3 x 7 split plot arrangement with three nozzle types (XR11002, DG11002 and AIXR11002) and seven distances (2, 3, 4, 5, 6, 7, 12 m) downwind from nozzle. The spray time for each repetition was 10 seconds. The nozzles had the same flow rate (0.66 L min^{-1}) at a pressure of 207 kPa (30 psi) which was constant for all applications. This study was conducted following the ISO 22856-1 Standard, with some modifications. At each distance, round strings with 2 mm diameter and 1 m length were set up perpendicularly to the wind flow 10 cm above the floor of the wind tunnel. The distance between the nozzle and floor of the wind tunnel was 0.6 m. As source of glyphosate and 2,4-D amine, the commercial products used were Roundup PowerMax® (2.34 L ha^{-1}) and DMA 4 IVM™ (1.179 L ha^{-1}), respectively. The spray concentration was prepared simulating an application at 94 L ha^{-1}. A fluorescent tracer (1,3,6,8 pyrene tetra sulfonic acid tetra sodium salt) at 0.6 mg L^{-1} was used to quantify flux using fluorimetry. After the application, the collectors were put individually into plastic bags and then washed with 40 mL of a solution that consisted of 90% v/v distilled water and 10 v/v of 91% isopropyl alcohol. Each sample was analyzed by fluorimeter and raw fluorescence was converted into percentage of drift. In general, across wind speeds, the smallest and highest percentages of drift were produced by AIXR and XR nozzles, respectively. For nozzles, when the wind speed was increased, a higher percentage of drift was observed. This is consistent with what has been reported in the literature for other types of trials of this nature.

INFLUENCE OF APPLICATION SPEED ON DROPLET SIZE DISTRIBUTION IN AERIAL APPLICATIONS OF GLYPHOSATE AND ADJUVANTS. Bruno Canella Vieira*, Fernando Kassis Carvalho, Guilherme Sousa Alves, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (117)

Glyphosate is one of the most widely used herbicides worldwide because of its high efficacy, low toxicity to humans, and relatively low cost and low environment impact. Drift is one of the most hazardous consequences of an improper aerial application of glyphosate. Wind, droplet size, application height and speed are the most important factors for drift. Droplet size is affected by nozzle, operating pressure, flight speed, deflection angle, and physical-chemical properties of the spray solution. Therefore, the objective of this research was to evaluate the effect of flight speed and the use of adjuvants on droplet size spectra in glyphosate aerial applications. The study was conducted in a high-speed wind tunnel at the Pesticide Application Technology Lab (University of Nebraska – Lincoln, West Central Research and Extension Center, North Platte, NE, U.S.). Glyphosate aerial applications were simulated with different application speeds (160, 190, 220, 250 km h^{-1}) and glyphosate solutions combined with adjuvants (high surfactant oil concentrate, drift reduction agent, nonionic surfactant, polymer, and glyphosate alone). Applications were performed using a CP11-8006 nozzle at 276 kPa. Droplet size spectra were evaluated using a Sympatec Helos laser diffraction instrument measuring 45 cm from the nozzle tip. The volumetric median diameter (VMD) and the percentage of droplets smaller than 100 µm were reported. Glyphosate solutions with adjuvants had a larger VMD than the glyphosate alone solution at 160 km h^{-1} wind speed. At 250 km h^{-1} only the glyphosate solution with polymer had a larger VMD. Conversely, it had the greatest percentage of droplets smaller than 100 µm. The proper configuration of an aerial application is a key factor to achieve a successful weed control while mitigating unintended effects to the surrounding environment.

ATRAZINE FORMULATIONS AND ADJUVANTS EFFECT ON DROPLET SIZE DISTRIBUTION IN AERIAL APPLICATIONS. Fernando Kassis Carvalho*[1], Bruno Canella Vieira[1], Guilherme Sousa Alves[1], Ryan S. Henry[1], Ulisses R. Antuniassi[2], William E. Bagley[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]FCA-UNESP, Botucatu, Brazil, [3]Bagley Enterprises, San Antonio, TX (118)

The use of techniques to mitigate spray drift is important when spraying pesticides. Understanding the interaction between pesticide formulations and adjuvants can help choose effective techniques to reduce spray drift. The objective of this work was evaluate the effect of atrazine formulations and adjuvants on droplet size distribution in aerial applications. The experiment conducted at the PAT Lab in North Platte, NE, measured the Volume Median Diameter (VMD), Relative Span (RS) and percentage of droplets less than 100 µm (%<100 µm) of the spray solutions. Droplet size distribution was measured in a high-speed wind tunnel coupled with a Sympatec HELOS/KR laser diffraction system. Two formulations of atrazine at 350 g ae ha^{-1} were selected, a liquid formulation and a dry formulation, suspension concentrate (SC) and water-dispersible granule (WG) respectively. They were applied with and without oil-based adjuvants in the spray solution. The treatments were defined by the interaction of the spray solutions and the wind speeds (175, 215, 230 and 250 km h-1). The CP11TT-4020 nozzle at 0 degree of deflection and 275 kPa was used to apply the solutions. The WG formulation of atrazine had the highest VMD across wind speeds compared with the other treatments with or without adjuvants. The adjuvants decreased the VMD for the SC and WG formulations at the wind speeds tested. Above 215 km h^{-1} the adjuvants increased the %<100 µm for the treatments. The adjuvants tested altered the droplet distribution, increasing the drift potential for both atrazine formulations above 215 km h^{-1}.

INFLUENCE OF ADJUVANTS ON DICAMBA VOLATILITY AND EFFICACY. Jamie L. Long*[1], Bryan Young[2], Julie M. Young[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Layfette, IN (119)

The anticipated commercialization of dicamba-tolerant soybean will lead to more prevalent applications of dicamba and new application timings of this herbicide leading to concerns of off-target herbicide movement from spray particle and vapor drift. Various spray application factors may affect the amount of dicamba volatility in the field and previous research documented greater amounts of vapor drift may occur on plant surfaces compared to bare soil. Therefore, a field experiment was conducted in Lafayette, IN to determine dicamba vapor movement as influenced by target surface of the sprayed area and the addition of different herbicide adjuvants. Greenhouse flats with bare soil or with an established vegetative canopy from a corn/soybean mixture represented two spray target surfaces (soil vs. vegetation). Dicamba (dimethylamine salt) was applied at 1.1 kg ha^{-1} to promote higher levels of vapor evolution to improve the detection of differences between treatments. Four herbicide treatments included a no dicamba control, dicamba alone (no adjuvant), dicamba plus methylated seed oil (MSO; 1% v/v), and dicamba plus an oil emulsion drift control agent (280 ml ha^{-1}). Field plots were 6 m wide by 15 m long which allowed for eight soybean rows with a 76-cm spacing. In the center of each plot a 4.6 m by 2.4 m open-ended low tunnel covered with plastic was placed over the center two rows. All treatments were applied to the greenhouse flats at a remote location to prevent any spray particle drift to the experimental plots. Within five minutes of the herbicide application the flats were transported to assigned field plots and placed under the center of the plastic tunnels between the two soybean rows. Each tunnel contained two greenhouse flats, to serve as a source for dicamba vapor, and remained in the tunnel for 48 h. Visual estimates of soybean injury within the soybean rows were recorded using a scale adapted from Behrens and Lueschen (1979) in 0.5-m increments from the center of the plastic tunnel to the end of the plots 3, 7, 14, 21, and 28 d after treatment (DAT). At 28 DAT soybean plant height and node counts were collected. At 14 and 28 DAT soybean injury from dicamba applied to a bare soil surface was 9% or less on plants immediately adjacent to the dicamba vapor source. Conversely, soybean injury from dicamba applied to flats with corn/soybean vegetation was 15 to 24%. Contrary to our original hypothesis that the addition of an adjuvant would decrease dicamba volatility from a plant surface, the addition of an adjuvant only reduced volatility from applications made to bare soil. For example, soybean injury from the application of dicamba alone to bare soil was 9% at 14 DAT and was reduced to 1.3% soybean injury for the application of dicamba plus MSO. The application of dicamba plus MSO to corn/soybean vegetation resulted in 24% soybean injury at 14 DAT and was not different from dicamba applied alone (18%). Preliminary research suggests that environmental factors, specifically air temperature, may influence the response of dicamba volatility from the addition of adjuvants applied with dicamba to plant surfaces. This field experiment will be conducted again in 2016 to further investigate the role of various environmental conditions on the influence of adjuvant on dicamba volatility.

ADJUVANTS WITH NANO-TECHNOLOGY. Rich Zollinger*[1], Kirk Howatt[1], Tom Peters[1], Bryan Young[2], Dallas Peterson[3], Mark Bernards[4]; [1]North Dakota State University, Fargo, ND, [2]Purdue University, West Layfette, IN, [3]Kansas State University, Manhattan, KS, [4]Western Illinois University, Macomb, IL (120)

Adjuvants are used to enhance the activity of postemergence herbicides. Nanotechnology is a new area of research and product development in numerous sectors. Nanoparticles are one-billionth of a meter (<100 nm) in size and have a high surface area to volume ratio that can provide many binding sites to carry pesticides across the cuticle. Commercial nano-adjuvants claim to contain nano-technology (carbon based nano-tubes) that increases absorption of herbicides thus increasing control of hard-to-control and herbicide-resistant weeds. The nano-adjuvants purportedly would over-come resistance mechanisms by promoting higher levels of herbicide penetration into the plant. Increased herbicide absorption likely would not overcome the underlying mechanisms of herbicide resistance, and the suggestion that the only necessary action to control glyphosate-resistant weeds is to apply glyphosate with the nano-adjuvant could be inadequate. In 2015, field trials were conducted in North Dakota, Indiana, Illinois, and Kansas on different biotypes of glyphosate-resistant weeds, namely waterhemp (four biotypes), Palmer amaranth (two), common ragweed (two), and kochia (three). Glyphosate was applied at 0.75 lb/A alone, with surfactant (NIS) plus ammonium sulfate (AMS), and with two different commercial adjuvants containing nano-tubes at 2 and 4 fl oz/A. Species were 10 to 20 cm tall at application with the exception of one waterhemp study where plant size was 35 cm tall. Studies included nano-adjuvants premixed and not premixed with glyphosate herbicide prior to adding to spray solution. Glyphosate plus nano-adjuvants did not control any glyphosate-resistant weed species tested. Weed control from glyphosate plus nano-adjuvants was similar or better than glyphosate alone but not better than glyphosate plus NIS plus AMS. Nano-adjuvants applied alone without glyphosate did not cause visible plant phytotoxicity. Weed control from additional studies conducted on herbicide susceptible species showed nano-adjuvants to give similar results as other adjuvant standards used.

WEED SEED DORMANCY AND PERSISTENCE IN THE SOIL SEEDBANK ARE RELATED. Adam S. Davis*[1], Xianhui Fu[2]; [1]USDA-ARS, Urbana, IL, [2]Uiniversity of Illinois, Urbana, IL (121)

Ruderal weeds form soil seedbanks capable of persisting for years to decades. Integrated weed management strategies will benefit from including methods of reducing weed seedbank persistence, yet knowledge of seed traits driving persistence in the soil seedbank remains limited. To address this knowledge gap, we conducted a field study of the relationship between biological, chemical and physical seed defense traits and weed seed persistence in the soil seedbank in Savoy, IL, over a five year period, from 2007 to 2012. Twelve species were included in the study: *Abutilon theophrasti* (velvetleaf), *Alliaria petiolate* (garlic mustard), *Amaranthus tuberculatus* (common waterhemp), *Ambrosia trifida* (giant ragweed), *Chenopodium* *album* (common lambsquarters), *Ipomoea hederacea* (ivyleaf morningglory), *Kochia scoparia* (kochia), *Panicum miliaceae* (wild proso millet), *Polygonum pensylvanicum* (Pennsylvania smartweed), *Setaria faberi* (giant foxtail), *Setaria lutescens* (yellow foxtail), and *Thlaspi arvense* (field pennycress). Seeds were buried at a depth of 2.5 cm in wire-mesh trays protected from vertebrate seed predators. Nonlinear mixed-effects models of seed persistence over time were used to estimate seed half-lives ($t_{0.5}$) in the soil seedbank, which ranged from 0.25 to 2.22 years. Multivariate models of $t_{0.5}$ in relation to seed defense traits indicated a primary role of seed dormancy in regulating weed seed persistence in the soil seedbank, with secondary contributions from chemical and physical defense mechanisms. Seed dormancy showed a positive linear relationship to $t_{0.5}$ (slope = 0.050, $p<0.001$, $R^2 = 0.92$), while the variance of seed dormancy followed a negative nonlinear relationship with $t_{0.5}$. Weed seedbank management strategies that keep weed seeds near the soil surface can take advantage of rapid depletion of soil seedbanks due to germination losses.

INFLUENCE OF TILLAGE, SOIL MOISTURE AND SOIL TEMPERATURE ON WATERHEMP EMERGENCE. Joey M. Heneghan*, William G. Johnson; Purdue University, West Lafayette, IN (122)

Waterhemp (*Amaranthus tuberculatus* var. *rudis*) is a small-seeded broadleaf weed and has been observed to germinate at shallow soil depths. No-till 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. Two field experiments were conducted in 2014 and 2015 to evaluate the influence of tillage, soil moisture and soil temperature on waterhemp emergence. Soil moisture and volumetric water content were recorded in each experiment as was air temperature. The first experiment evaluated season-long emergence from a fallow area with three tillage regimes; no-till, a single tillage event on May 1, and two tillage events on May 1 and June 1. The May 1 tillage was to imitate seedbed preparation and the June 1 tillage was to imitate interrow crop cultivation. Emerged seedlings were removed weekly. The second experiment compared the effect of no-till 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, 2014 and May 14, 2015 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*-metolachlor at 1,395 g ai ha^{-1}. Emerged seedlings were counted and removed bi-weekly. In the first experiment, no differences were observed in 2014 due to low weed density. In 2015, waterhemp emergence after the May 1 tillage event was higher in the no-till compared to either treatment with tillage. After the June 1 tillage event, waterhemp emergence was higher in the two tillage treatment compared to the no-till and single tillage treatment. At the end of the season, emergence was lowest in the single tillage treatment and similar between the no-till and double tillage treatments. In the second experiment, when flumioxazin and *s*-metolachlor was applied, there was no waterhemp emergence in either tillage system. In the absence of residual herbicides, overall emergence was higher in the no-till treatments. There was minimal waterhemp emergence in either system beyond 10 weeks after planting. Soil moisture in the no-till systems was consistently higher than the tilled areas while no definitive trend was observed in soil temperatures. Waterhemp emergence can be decreased with conventional tillage when compared to no-till, but repeated shallow tillage operations in one season can promote waterhemp emergence.

DOES WATERFOWL MIGRATION = WEED SEED DISTRIBUTION? Jaime A. Farmer*[1], Mandy D. Bish[2], Alex R. Long[3], Meghan E. Biggs[3], Kevin W. Bradley[3]; [1]University of Missouri-Columbia, Columbia, MO, [2]University of Missouri, 65211, MO, [3]University of Missouri, Columbia, MO (123)

Migratory waterfowl have often been implicated in the movement of troublesome agronomic weed species. Previous research has shown that migratory waterfowl have the ability to transport invasive wetland weed species. However, little to no research has been conducted to investigate the long-distance dispersal of agronomic weed species such as Palmer amaranth and waterhemp. Thus, two objectives were set forth for this research project. The first was to determine what weed species are being transported throughout Missouri by ducks and snow geese. Beginning in the fall of 2014, 238 ducks and 111 snow geese were collected from Missouri waterfowl hunters. These birds were dissected to remove weed seed from each bird's esophagus, gizzard and intestines. Recovered seeds from each section were then planted by individual organ section in the greenhouse. Emerged seedlings were identified by species, counted, and removed from the flats every two weeks for three months. Almost 15,000 weeds representing over 50 distinct species emerged from the seed recovered from the hunter-harvested ducks. The three species representing the largest portion of the emerged weeds were barnyardgrass, *Amaranthus* species, and smartweed species at 5494, 4311, and 3454 plants, respectively. Waterhemp made up the second largest recovered species within the esophagus, gizzard and intestines at 38, 11, and 19%, respectively. Currently 86 plants representing 11 species have emerged from the hunter-harvested snow geese. Presently, the three plants most commonly recovered from dissected organs are corn, smartweed species and *Amaranthus* species at 45, 30, and 9%, respectively. Thus far, Palmer amaranth has emerged from the intestines of at least one snow goose. These results indicate that waterfowl, particularly ducks, are consuming many agronomic weeds, including waterhemp and Palmer amaranth, and transporting them throughout Missouri with the potential to disperse these seeds over long distances. The second objective of this study was to determine the recovery rate and viability of 13 agronomic weed species after passage through a duck's digestive system. A feeding study was conducted on live mallards in the summer of 2015 and repeated in the fall of 2015. Adult mallards were precision fed 1-gr meals of a known quantity of seed from 1 of 13 different agronomically important weed species. The ducks were placed into individual cages immediately after feeding where each duck's fecal samples were collected every four hours up to 48 hours after feeding. The experimental design consisted of an incomplete block design of 13 treatments and four replications of the feeding experiment. Across the four replications, no two ducks were fed the same four weed species as another duck. Each weed species was fed to an equal number of male and female mallards. The fecal samples were rinsed in sieves and recovered seed was collected, counted, and stored for future viability testing. Data were subjected to analysis through a PROC GLIMMIX procedure in SAS using a logit link function and means were separated using Fisher's Protected LSD ($P \leq 0.05$). Data from the feeding study also supported the potential for long distance dispersal of weed seed through waterfowl consumption. Intact seed was recovered from 11 of the 13 weed species fed. Waterhemp and Palmer amaranth seed recovery was different at 19 and 12%, respectively, within the 48 hr monitoring period. These preliminary results show the potential for waterfowl to provide long distance dispersal of agronomic weed species. Future plans include testing the viability of seed recovered in the feeding study as well as a second year of collecting ducks and snow geese from Missouri waterfowl hunters.

KOCHIA (*KOCHIA SCOPARIA*) AND RUSSIAN THISTLE (*SALSOLA TRAGUS*): GLYPHOSATE-RESISTANCE AND DISTRIBUTION IN WESTERN NEBRASKA. Spencer L. Samuelson*, Bruno Canella Vieira, Chandra J. Hawley, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (124)

Despite knowing that there are several weeds with glyphosate resistance, overall distribution and frequency of glyphosate-resistant weeds in Nebraska is unknown. The objective of this study was to determine frequency and distribution of glyphosate-resistant kochia (*Kochia scoparia (L.) Schrad.*) and Russian thistle (*Salsola tragus L.*). Collection of kochia and Russian thistle populations were made in Nebraska by traveling the state and arbitrarily selecting from fields that were abundant with escapes during the falls of 2013-2015. Plant seed heads were harvested from 20 individual plants and dried at 20 C for three weeks. Seeds were germinated in a greenhouse and treated using a single nozzle research track sprayer calibrated to deliver 94 L/ha at 414 kPa, with a Teejet AI9502EVS nozzle with glyphosate at the varying rates: 0, 217, 434, 868, 1736, 3472, and 6946 g ae/ha when plants were 10-15 cm tall. Visual estimations of injury were recorded 28 days after treatment (DAT) on a scale of 0-100 (0 being no effect from herbicide and 100 being complete control). Living plants at 28 DAT were severed at the base and dried at 65 C for 72 hours and dry weights were recorded. Data were fitted to a non-linear regression model using the drc package in R 3.1.2. The I_{50}, I_{90}, GR_{50}, and GR_{90} values were estimated for each population using a four parameter log logistic equation: y=c+(d-c/1+exp(b(logx-loge))). Data confirms the presence of glyphosate-resistant kochia in the state of Nebraska. At this point, we have not observed resistance to glyphosate in Russian thistle despite finding many problematic weed escapes throughout the western part of the state. Results from this survey will assist growers in understanding where resistant populations are located in the state, and hopefully will encourage them to follow proper application techniques, discourage them from continued use of the same herbicide mode of action, and impede the further evolution and spread of herbicide-resistant weeds in Nebraska and the Midwest U.S.

FITNESS DIFFERENCES AMONG GLYPHOSATE-RESISTANT AND -SUSCEPTIBLE KOCHIA POPULATIONS IN WESTERN KANSAS. O. Adewale Osipitan*[1], Anita Dille[2], Philip W. Stahlman[3], David C. Hartnett[2], Allan K. Fritz[2]; [1]Agronomy Department, Kansas State University, Manhattan, KS, [2]Kansas State University, Manhattan, KS, [3]Kansas State University, Hays, KS (125)

The development and dissemination of herbicide-resistant weeds pose a significant threat to modern agriculture. Mechanism for glyphosate resistance in kochia is reported to be gene amplification of 5-enolpyruvylshikimate-3-phosphate synthase (*EPSPS*). Results have shown that glyphosate resistance in kochia increases with increase in EPSPS gene copy. Ecological fitness is important in describing the evolutionary advantage of a biotype. Ecological fitness measures the survivorship, fecundity and competitiveness of a plants in a population. A field study was conducted near Manhattan, Kansas in summer 2014 to evaluate the ecological fitness of six kochia populations from Finney, Scott, Thomas, Phillips, Wallace and Wichita counties in western Kansas. Dose response studies in the greenhouse showed that populations from Finney, Scott and Thomas counties were glyphosate resistant (Gly-R) while populations from Phillips, Wallace and Wichita were glyphosate susceptible (Gly-S). The field experiment was laid out in a randomized complete block design (RCBD) with 10 replications. Kochia plants were directly seeded in the field. The competition design used was neighborhood design. One individual target kochia plant was surrounded by one of the three densities of neighbor kochia plants: equivalent to 12, 35 and 70 kochia plants m^{-2}. Ecological fitness data collected on the target plants include plant height and stem diameter at different stages of growth, days to first flowering, plant biomass at harvest, number of seeds per plant, neighbor densities at emergence and at harvest, and EPSPS gene copy number of each population. The quantification of EPSPS gene copy number of the populations' genomic DNA using real time polymerase chain reaction (qPCR) showed that at least 71% of the individuals from the three Gly-R populations have high gene copy numbers ranging from four to 14 while the three Gly-S populations have gene copy numbers that were less than two. These further confirmed our results from dose response in classification of these populations into Gly-R or Gly-S. Some individuals in the three Gly-R populations have lower gene copy numbers comparable to the susceptible populations which implies that the Gly-R populations are still segregating for glyphosate resistance. Plant height of populations follow similar trend at increasing stages of growth. Gly-R population from Scott County was the tallest (118.8 cm) and Gly-R from Thomas County was the shortest (92.7 cm) when comparing the six populations at physiological maturity, though not different at α = 0.05. There was no difference between the Gly-R and Gly-S populations in respect to stem diameter at physiological maturity, total plant biomass at physiological maturity, days to first flower as well as total seed production across the neighbor densities. Similarly, genetic background of the kochia populations that described glyphosate resistance or susceptibility as shown by the EPSPS gene copy numbers did not translate into fitness differences among these populations. These results may imply that glyphosate-resistant kochia plants with high EPSPS gene copy numbers did not show superior or inferior ecological fitness, and are likely to persist in field populations, even in the absence of glyphosate application.

POLLEN-MEDIATED GENE FLOW FROM GLYPHOSATE-RESISTANT TO -SUSCEPTIBLE COMMON WATERHEMP UNDER FIELD CONDITIONS. Debalin Sarangi*[1], Stevan Z. Knezevic[2], John L. Lindquist[3], Suat Irmak[1], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]University of Nebraska- Lincoln, Lincoln, NE (126)

Glyphosate-resistant common waterhemp (*Amaranthus rudis* Sauer) is one of the most encountered and troublesome weeds in the midwestern U.S. It is a dioecious and anemophilous species having small spherical-shaped pollen grain designed to travel long distances downwind. Pollen-mediated gene flow (PMGF) may aid in the rapid spread of herbicide resistant alleles from resistant to susceptible biotypes. However, there is a lack of information about PMGF from glyphosate-resistant to -susceptible common waterhemp under field conditions. The objective of this study was to quantify PMGF in glyphosate-resistant common waterhemp. Field experiments were conducted in 2013 and 2014 at Clay County, NE using a concentric donor (10 m diam; 80 sq m)-receptor (80 m × 80 m) design, in the form of a Nelder wheel. Glyphosate-resistant common waterhemp plants were transplanted in the pollen-donor block. The pollen-receptor area was divided into eight directional blocks (cardinal: N, S, E, and W; ordinal: NE, NW, SE, and SW) and plants from a known glyphosate-susceptible biotype were transplanted at specific distances up to 50 m from the donor block. Surface meteorological data (hourly), flowering synchrony between donor and receptor, and pollen release height from donor plants were recorded. The seeds from the female glyphosate-susceptible plants (pollen receptor plants) were harvested separately and at least 400 seedlings from each distance/block were grown in the greenhouse to determine the gene flow frequency by using glyphosate-resistant trait as a selective marker. Frequency of gene flow declined exponentially with distance from the source. Depending upon the average wind speed and direction, maximum gene flow (up to 77%) was observed near to the pollen-source (0 to 0.1 m). Relatively low gene flow (< 10%) was observed at the greatest distance (50 m) investigated in this study. In conclusion, pollen mediated gene flow is one of the primary contributors to the spread of herbicide resistance in common waterhemp.

CHARACTERIZATION OF A NOVEL FIVE-WAY RESISTANT POPULATION OF WATERHEMP *AMARANTHUS TUBERCULATUS*. Cody M. Evans*[1], Patrick Tranel[2], Dean E. Riechers[3], Adam S. Davis[4], Doug Maxwell[1], Lisa Gonzini[1], Aaron G. Hager[2]; [1]University of Illinois, Champaign, IL, [2]University of Illinois, Urbana, IL, [3]University of Illinois Urbana-Champaign, Urbana, IL, [4]USDA-ARS, Urbana, IL (127)

Waterhemp (*Amaranthus tuberculatus*) is one of the most problematic weed species with which Illinois soybean and corn growers must contend with each growing season. This is due in part to the evolution of resistances to herbicides from multiple site-of-action families, which is facilitated by waterhemp's dioecious biology and genetic diversity. In 2012, an Illinois grower reported a population of waterhemp in Champaign County, Illinois was not controlled with topramezone. Initial greenhouse screenings of the population, designated CHR, revealed putative resistance to herbicides from five sites-of-action families. Additional greenhouse and laboratory experiments were performed to determine the response of CHR to herbicides from five site-of-action families. Dose response experiments conducted on progeny generated from field-collected seed produced resistance ratios of 16-, 30-, and 253-fold to mesotrione, 2,4-D, and atrazine respectively, when compared with a sensitive population. Molecular assays identified alterations in the coding sequence of ALS and PPO genes that are known to confer resistance to PPO- and ALS-inhibiting herbicides. Field studies conducted over a two year period supported the results from the greenhouse and laboratory experiments. Only glyphosate provided control >90% at a 1x application rate in foliar-applied herbicide experiments. Collectively, these results demonstrate CHR has evolved resistance to herbicides from five site-of-action families, greatly diminishing the number of viable herbicide options for its management in corn or soybean.

SIGNIFICANCE OF CROP SEED SIZE AND COVER CROP RESIDUES ON EDAMAME (GLYCINE MAX)-WEED INTERACTIONS. Laura E. Crawford*[1], Martin Williams II[2], Samuel Wortman[1]; [1]University of Illinois, Urbana, IL, [2]USDA, Champaign-Urbana, IL (128)

Two major challenges for edamame (*Glycine max*) production in the U.S. are weed interference and poor crop emergence. Certain cultural weed management tactics, including crop seed size and cover crop residues, are known to influence crop emergence and weed interference in grain-type soybean. However, these tactics have not been studied in relation to edamame, a crop with larger seed more susceptible to soil crusting than grain-type soybean. Two field experiments were conducted to evaluate these tactics in edamame. The first objective was to identify cover crop residues providing weed suppression without compromising crop emergence. Twelve cultivars were planted into a bare soil control and five cover crop residues, including: winter-killed radish, early-killed canola, early-killed rye, late-killed canola, and late-killed rye. Relative to the bare soil control, late-killed rye reduced crop emergence 27.3%, and early-killed canola actually improved crop emergence 7.9%. Other treatments had no effect on crop emergence. Mid-season weed biomass was reduced between 44.8 and 97.6% by early-killed rye, late-killed canola, and late-killed rye. The objective of the second study was to determine the extent to which edamame seed size and cultivar affects crop emergence and weed suppressive ability. Six cultivars were divided into two discrete seed size classes, hereafter called 'large' and 'small', and planted with or without velvetleaf. With the exception of one cultivar unaffected by seed size, the large seed class had about 6% higher emergence than the small seed class. Large seeds only marginally suppressed mid-season velvetleaf biomass (P=0.085); however, cultivars differed up to 70.7% in their weed suppressive ability. Solutions to certain problems facing domestic edamame production could lie in the development of multi-tactic weed management systems. Preliminary results indicate certain cover crop residues (i.e. early-killed rye and late-killed canola) selectively suppress weed growth without compromising crop emergence. Likewise, there appears to be a benefit to crop establishment and weed management by using larger seed of certain cultivars.

CRITICAL DURATION OF GRASS WEED INTERFERENCE IN GRAIN SORGHUM. Gared E. Shaffer*, Anita Dille; Kansas State University, Manhattan, KS (129)

The anticipated release of ALS-inhibitor herbicide-resistant grain sorghum hybrids provide an opportunity to control grass weeds POST with the ALS-inhibiting herbicide nicosulfuron (Zest™), which requires more information on grass weed impacts on grain sorghum. Research objectives are to determine the critical duration of grass weed competition in grain sorghum with different crop row spacing and seeding rates, and to evaluate the timing of grass weed removal on grain sorghum yield. Field studies were conducted in 2014 and 2015 at two locations in KS. This study was established at the KSU Agricultural Research Center at Hays, KS and the KSU Department of Agronomy Research Farm near Manhattan, KS. Four main treatments were grain sorghum row spacing's of 25 and 76 cm at Hays, 20 and 76 cm at Ashland Bottoms and two seeding rates of 120,000 and 150,000 seed/ha. Within each of these main plots, seven treatments were established including: weed-free all season using PRE herbicides at Manhattan 2014: 1463 g ai/ha S-metolachlor, 1463 g ai/ha atrazine, and 185 g ai/ha mesotrione; Manhattan 2015: 1885 g ai/ha S-metolachlor , 708 g ai/ha atrazine, and 188 g ai/ha mesotrione; Hays 2014: 400 g ai/ha acetochlor and 199 g ai/ha atrazine; Hays 2015: 271 g ai/ha S-metolachlor and 217 g ai/ha atrazine, weed-free all season by hand, weedy for 2, 3, 4, and 5 weeks after crop emergence in 2014 and changed to be weedy for 2, 4, 6 and 8 weeks after crop emergence in 2015, and weedy throughout the growing season. The key grass weeds were giant, green and yellow foxtail, as well as large crabgrass and barnyardgrass. Grass weed biomass was collected from a 0.25m^2 quadrat within corresponding treatments during weeks one through eight and wk 20 after crop emergence. Grass weed biomass fluctuated throughout growing season in 2014 due to periods of wet and dry conditions, but in 2015 grass biomass increased at both locations over time. Whole plant grain sorghum biomass at crop harvest was collected from 1-m^2 quadrat and differed due to grass competition that occurred in different seeding rates and row spacing combinations. The highest grain sorghum biomass was observed in 76cm row width and high seeding rate of 150,000 seeds/ha in both locations in 2014 and 2015. With much grass weed competition, grain sorghum yields differed between the weed-free all season by hand and weedy all season treatments. In Hays in 2014, the yield in the weed-free by hand treatments was 9070 kg/ha and was 20% more than the yield in weedy all season plots that was 7320 kg/ha. Removing grass competition over a two to four week period after crop emergence maintained grain sorghum yields.

MODELING SHATTERCANE POPULATION DYNAMICS IN A HERBICIDE-TOLERANT SORGHUM CROPPING SYSTEM. Rodrigo Werle*[1], Brigitte Tenhumberg[2], John L. Lindquist[1]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (130)

Traditional breeding technology is currently being used to develop grain sorghum germplasm that will be tolerant to acetolactate synthase (ALS)-inhibiting herbicides. This technology (Inzen, DuPont) has the potential to improve sorghum production by allowing for the postemergence control of traditionally hard-to-control grasses in the U.S. Grain sorghum and shattercane can interbreed and introduced traits such as herbicide tolerance could increase the invasiveness of the weedy relative. Moreover, ALS-resistance in shattercane populations has been reported, indicating that over-reliance on ALS-chemistry may also select for resistant biotypes. The objective of this research was to develop a simulation model to assess management options to mitigate risks of ALS-resistance evolution in shattercane populations in U.S. sorghum production areas. Assuming a single major gene confers resistance and gene frequencies change according to the Hardy-Weinberg ratios we constructed a stage-structured (seedbank, plants) matrix model with annual time steps. The model explicitly considered gene flow from Inzen plants to shattercane populations. The management strategies considered in the model were: a) continuous sorghum, b) sorghum *fb* soybeans and c) sorghum *fb* fallow *fb* wheat, where postemergence ALS-herbicides were only used in Inzen years. During sorghum years, two options were tested: continuous Inzen and Inzen *fb* conventional sorghum. The parameter values used in the model were obtained from our research, the literature, and expert opinion. Evolution of resistance was predicted to occur rapidly if Inzen sorghum is planted continuously because of high selection pressure (ALS-herbicide application) and gene flow. The time for resistance evolution was predicted to decrease with increased cropping system complexity (more crop diversity than continuous production of Inzen). Crop and herbicide rotation will be key strategies to postpone the evolution of ALS-resistance in shattercane.

ABILITY OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS*, CAUSAL AGENT OF GOSS&RSQUO;S WILT OF CORN, TO OVERWINTER ON ALTERNATIVE HOSTS. Joseph T. Ikley*, Kiersten A. Wise, William G. Johnson; Purdue University, West Lafayette, IN (131)

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. Since reemerging, Goss's wilt has been identified in 17 states. Among corn diseases, Goss's wilt is currently the third-leading cause of yield loss in the US and Canada, with an estimated loss of seven million metric tons in 2013. The cause of the reemergence and spread of the disease is unknown, but has been attributed to an increase in hectacres planted corn-on-corn, an increase in no-tillage practices, and wide-spread use of corn hybrids that are susceptible to Cmn. Some grass weed species and cover crops have been documented as additional hosts of Cmn, although their role as an additional source of inoculum has not been researched. To answer this question, two studies were initiated to research the potential of Cmn to overwinter on alternative hosts. In the first study, giant foxtail, large crabgrass, and a Cmn-susceptible corn hybrid were inoculated with a bacterial suspension containing 1 x 10^8 colony-forming units (CFU) of Cmn per mL. Plants with confirmed symptoms were buried in a field near West Lafayette, Indiana at 0 and 10 cm below the surface. Plant debris was sampled every four months for two years to determine how long Cmn remains pathogenic in host plant tissue. Results from this study reveal that Cmn can overwinter on both corn and alternative host debris in Indiana for up to four months, but no pathogenic Cmn was recovered at or after the eight month sampling period. In the second study, annual ryegrass, giant foxtail, and johnsongrass were inoculated in the greenhouse with a bacterial suspension containing 1 x 10^8 CFU of Cmn per mL at three different growth stages: three-collar growth stage (V3) + six-collar growth stage (V6) + seed-head emergence, V6 + seed-head emergence, and seed-head emergence only. Plants were grown to maturity and seed were collected from all plants. Seed were tested in the lab for the presence of Cmn inside the seed. Preliminary results reveal no indication of systemic infection on any species tested. Results from these studies help reveal more about potential sources of inoculum for this bacteria.

ALTERNATIVE HOSTS RESPONSE TO INOCULUM LEVELS OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS* . Taylor M. Campbell*[1], Joseph T. Ikley[2], Kiersten A. Wise[2], William G. Johnson[2]; [1]Purdue University, Lafayette, IN, [2]Purdue University, West Lafayette, IN (132)

Goss's wilt is a bacterial disease in corn caused by *Clavibacter michiganensis* subsp. *nebraskensis.* The primary source of inoculum is infected corn debris, but other hosts for this disease have been discovered. Other hosts include johnsongrass (*Sorghum halepense*), shattercane (*Sorghum bicolor*), giant foxtail (*Setaria faberi*), green foxtail (*Setaria viridis*), yellow foxtail (*Setaria pumila*), bristly foxtail (*Setaria verticillata*), large crabgrass (*Digitaria sanguinalis*), and annual ryegrass (*Lolium multiflorum*). These hosts have been confirmed in the greenhouse, but none have been found naturally infected in the field. The objective of this study was to evaluate johnsongrass, giant foxtail, annual ryegrass, a susceptible corn hybrid, and a moderately-resistant corn hybrid to determine the lowest inoculum concentration required to cause infection and compare their levels of susceptibility to Cmn. Plants were wounded with two different methods of inoculation and lesion expansion was measured for the two methods. Comparisons between the different species were made by calculating the total area under the disease progress curve and separated using Tukey's test. This study reveals that corn is the most susceptible host compared to the other hosts examined and is a bigger contributor to infected residue than alternative hosts. The alternative hosts showed responses to some of the lower inoculum levels and infection was seen consistently from all the alternative hosts at 1 x 10^4 colony forming units. These alternative hosts should be controlled, especially in fields with a history of Goss's wilt, as they can serve as "bridge" host in non-host crops.

INFLUENCE OF SPRING TILLAGE ON COMMON RAGWEED (AMBROSIA ARTEMISIIFOLIA L) EMERGENCE IN NEBRASKA. Ethann R. Barnes*[1], Rodrigo Werle[1], Lowell D. Sandell[2], Peter H. Sikkema[3], Stevan Z. Knezevic[4], John L. Lindquist[1], Amitkumar J. Jhala[5]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]Valent USA Corporation, Lincoln, NE, [3]University of Guelph, Ridgetown, ON, [4]University of Nebraska-Lincoln, Concord, NE, [5]University of Nebraska-Lincoln, Lincoln, NE (133)

Common ragweed (*Ambrosia artemisiifolia* L.) is a competitive annual weed species in soybean. Glyphosate-resistant common ragweed has been recently confirmed in Nebraska. Common ragweed emerges early in the season in Nebraska. Spring tillage 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 and 2015 in Gage County, NE in a grower's field where glyphosate-resistant common ragweed was confirmed. Tillage was simulated with a 50 cm wide rototiller operated at a depth of 10 cm. The experiment was designed as a randomized complete block with four replications. Treatments consisted of a no-tillage control and three tillage timings. The first tillage treatment was at the onset of emergence and subsequent treatments followed two and five wk later. Starting in April, on a weekly basis, common ragweed seedlings were counted and removed from three 0.3 m by 0.3 m quadrats placed within each block spaced 1.2 m apart. Tillage had no effect on total emergence (P=0.751) or on time to 50% emergence (P=0.395). The year had no effect on total emergence (P=0.893); however, time to 50% emergence was different between 2014 and 2015 (P=.0001). On average, 290 and 312 seedlings m^{-2} emerged in 2014 and 2015, respectively; with

50% cumulative emergence on May 4, 2014 and April 19, 2015. Most of the common ragweed seedlings emerged before soybean planting time and tillage treatments did not stimulate additional germination and emergence. This study concludes that spring tillage can be used as a component of an integrated weed management program for the control of glyphosate-resistant common ragweed in Nebraska.

EFFECTS OF SPRING TILLAGE ON GIANT RAGWEED (*AMBROSIA TRIFIDA*) EMERGENCE. Jared J. Goplen*[1], Jeffrey L. Gunsolus[2], Craig C. Sheaffer[3], Lisa M. Behnken[4], Fritz R. Breitenbach[5]; [1]University of Minnesota, Saint Paul, MN, [2]University of Minnesota Extension, St. Paul, MN, [3]University of Minnesota, St. Paul, MN, [4]University of Minnesota, Rochester, MN, [5]University of Minnesota Extension, Rochester, MN (134)

Control of giant ragweed is becoming increasingly difficult as herbicide-resistant biotypes become more widespread. To maintain acceptable control of giant ragweed, it is necessary to use integrated methods of control. Since giant ragweed is one of the earliest emerging weeds plaguing the Midwestern U.S., spring tillage has been proposed as an important non-chemical mechanism to control herbicide-resistant biotypes. This study was established in 2015 at two locations in Minnesota to evaluate the effect that different spring tillage timings have on both total emergence and time of emergence of giant ragweed. Tillage treatments were conducted with a field cultivator with a single pass of tillage at onset of giant ragweed emergence (April 28), with subsequent treatments at 14, 28, and 42 d after the onset of giant ragweed emergence. Additional treatments included a no-till control and tillage at emergence onset plus 28 days post-onset. Overall, giant ragweed emerged early, with 50 and 90% emergence occurring on May 12 and May 29, respectfully. Total and temporal patterns of giant ragweed emergence were affected by tillage treatment. However, tillage did not stimulate additional giant ragweed emergence. Emergence was reduced the wk following a tillage treatment, indicating that tillage likely disrupts and kills germinating seeds, thus minimizing emergence the following wk. The least giant ragweed emergence occurred when tilled at onset of emergence, likely because it controlled a larger percentage of seedlings that had germinated but not emerged compared to the other treatments. However, delaying tillage until several wks after emergence onset allowed a greater percentage of giant ragweed seedlings to germinate and emerge prior to tillage, resulting in improved control. These results suggest that tillage can be used as an effective mechanism to control herbicide-resistant giant ragweed without stimulating additional emergence.

CHARACTERIZATION OF HORSEWEED (CONYZA CANADENSIS) TOLERANCE TO A PPO-INHIBITING HERBICIDE. Joel E. Ream*, Li Wen, Paul Feng; Monsanto Company, Chesterfield, MO (135)

No abstract submitted

HERBICIDE PROGRAMS FOR CONTROL OF ATRAZINE- AND HPPD INHIBITORS-RESISTANT PALMER AMARANTH IN SEED CORN. Parminder S. Chahal*, Amit J. Jhala; University of Nebraska-Lincoln, Lincoln, NE (136)

Palmer amaranth, a dioecious summer annual, is one of the most troublesome weeds in the agronomic crop production systems of the U.S. Atrazine- and HPPD Inhibitor-resistant Palmer amaranth is of particular concern in south central Nebraska because of the proximity to intense seed corn production, which is heavily reliant on these herbicides for weed control. A field experiment was conducted in 2015 in a field infested with atrazine and HPPD-inhibitor-resistant Palmer amaranth near Shickley, Nebraska. The study was laid out in a randomized completed block design with seventeen herbicide treatments and three replications in seed corn. Herbicides were applied in a PRE followed by POST program. Palmer amaranth was controlled > 85% at 21 d after PRE application of atrazine, pyroxasulfone, and fluthiacet-ethyl pre-mixture and mesotrione, *S*-metolachlor, and atrazine pre-mixture. Most of the PRE followed by POST herbicide treatments improved Palmer amaranth control later in the season except when acetochlor was used as POST. At 28 d after POST application, > 90% Palmer amaranth control was achieved with atrazine, pyroxasulfone, and fluthiacet-ethyl pre-mixture PRE followed by POST application of pre-mixture of dicamba plus diflufenzopyr, acetochlor PRE followed by pre-mixture of dicamba plus diflufenzopyr POST, pre-mixture of mesotrione, *S* -metolachlor, and atrazine PR) followed by pre-mixture of dicamba plus diflufenzopyr POST. The percent shoot biomass reduction and visual control estimates of Palmer amaranth were similar for most of the treatments at 28 d after POST herbicides application. Most treatments provided higher yields (> 13500 kg ha^{-1}) compared with nontreated control.

CONFIRMATION AND CONTROL OF GLYPHOSATE-RESISTANT COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA*) IN NEBRASKA. Zahoor A. Ganie*[1], Ethann Barnes[2], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska- Lincoln, Lincoln, NE (137)

Common ragweed (*Ambrosia artemisiifolia* L.) is a native summer annual broadleaf weed of asteraceae family. Common ragweed is found in diverse agroecosystems, waste lands and has become prevalent in cropping systems using reduced or no-till practices. The objectives of this study were to quantify the level of glyphosate-resistance in a common ragweed population collected from southeast Nebraska and to evaluate the efficacy of POST corn and soybean herbicides for its control. Dose-response experiments were conducted in greenhouse (2014 and 2015) and field (2015) with the progeny of suspected glyphosate-resistant common ragweed plants that had survived the labelled rate of glyphosate in a soybean field. A known glyphosate-susceptible biotype was compared to determine the level of resistance. In addition, greenhouse experiments were conducted to evaluate the efficacy of

registered POST corn and soybean herbicides for control of susceptible and suspected glyphosate-resistant common ragweed biotypes. Percent visual control and biomass reduction data collected at 21 d after treatment (DAT) from the dose response study was fit to a four-parameter log-logistic model in drc package of R software. The ratio of ED_{90} values based on biomass reduction and visual control estimates for the two biotypes suggested presence of eight to 19-fold glyphosate-resistance in the suspected glyphosate-resistant common ragweed biotype. Results from the soybean POST herbicides evaluated in this study indicated >93% control with acifluorfen, fomesafen + glyphosate, lactofen, glyphosate + dicamba or 2, 4-D, glufosinate, and chlorimuron-ethyl + thifensulfuron-methyl. Corn POST herbicides evaluated in this study suggested >95% control with bromoxynil, glufosinate, mesotrione + atrazine, and diflufenzopyr + dicamba. Additionally, the results of control studies suggested reduced efficacy with acetolactate synthase ALS-inhibiting herbicides belonging to sulfonylurea (chlorimuron-ethyl) and imidazolinone (imazamox) families indicating the need of screening for multiple herbicide-resistance in this population.

DISTINCT GLYPHOSATE-RESISTANT PHENOTYPES IN GIANT RAGWEED ALTER THE MAGNITUDE OF RESISTANCE. Nick T. Harre*[1], William G. Johnson[2], Stephen C. Weller[2], Bryan G. Young[2]; [1]Purdue University, West Lafayette, IL, [2]Purdue University, West Lafayette, IN (138)

Management of giant ragweed via the use of herbicides has become increasingly difficult as populations have evolved resistance to glyphosate (GR). In Indiana, the last survey of the distribution of GR giant ragweed was performed nearly a decade ago in which two phenotypes were discovered: a rapid necrosis (RN) response whereby H_2O_2 accumulation destroys mature leaves within three days and a non-rapid necrosis (NRN) response that mimics traditional GR observed in other weed species. The magnitude of GR in populations with these phenotypes has not been previously compared, yet would provide insight towards a mechanism-of-resistance and potential fitness when exposed to glyphosate. Thus, research objectives were aimed to identify the current distribution of RN and NRN populations in Indiana, determine the magnitude of GR, and evaluate H_2O_2 production changes over time. Greenhouse testing confirmed there are currently 36 of 92 counties in Indiana with GR giant ragweed present compared to 14 counties reported in the last survey. Populations containing the RN phenotype were discovered in 16 counties, yet only five of these populations uniformly displayed this response. This suggests many GR populations consist of mixtures of NRN and RN individuals; however, the majority of populations in Indiana are of the NRN phenotype. Glyphosate dose response experiments were conducted to determine GR_{50} values for RN and NRN populations compared to a glyphosate-susceptible (GS) population. The magnitude of resistance (based on the R:S ratio of GR_{50} values) was 4.2 for NRN populations and 7.9 to 9.3 for RN populations. Production of H_2O_2 was quantified by staining leaf discs with 3,3'-diaminobenzidine at specific time intervals following glyphosate application of 0.42 and 1.68 kg ae ha^{-1} and analyzed using imagery software. H_2O_2 was detected within 0.5 hr after treatment (HAT) in the RN population treated with 1.68 kg ha^{-1} of glyphosate. For GS and NRN populations, H_2O_2 production was not evident until 16 and 72 HAT, respectively. Leaf discs taken from RN individuals reached maximum H_2O_2 content by four HAT when treated with 1.68 kg ha^{-1} of glyphosate and 36 HAT when treated with 0.42 kg ha^{-1} of glyphosate. Accumulation of H_2O_2 in the GS and NRN populations increased with time and glyphosate dose up to 72 HAT. Beyond this period, H_2O_2 production continued to increase in GS individuals and plateaued in NRN individuals. Although the NRN phenotype is currently more established in Indiana, these results indicate RN individuals have a higher level of GR and will likely become more prevalent if selection pressure through continued glyphosate use increases. Furthermore, differences in H_2O_2 accumulation confirm the severity of the RN response is dependent upon glyphosate dose and provides evidence suggestive of differing GR mechanisms between NRN and RN phenotypes.

INFLUENCE OF WEED HEIGHT ON THE SYNERGISM BETWEEN ATRAZINE AND HPPD-INHIBITORS IN TRIAZINE-RESISTANT PALMER AMARANTH. Jonathon R. Kohrt*, Christy L. Sprague; Michigan State University, East Lansing, MI (139)

Field experiments were conducted near Middleville, MI in 2013 and 2015 to determine the effect of weed height on the synergism between atrazine and HPPD inhibitors in a multiple (glyphosate, ALS-inhibitors, and atrazine)-resistant Palmer amaranth population. Herbicide treatments included: atrazine (560 g ha^{-1}) + COC (1% v/v), mesotrione (105 g ha^{-1}) + COC (1% vv^{-1}), topramezone (18 g ha^{-1}) + MSO (1% vv^{-1}), and tembotrione (92 g ha^{-1}) + MSO (1% vv^{-1}) applied alone and the HPPD inhibitors were applied in combination with atrazine. In 2015, the HPPD inhibitor, tolpyralate (40 g ha^{-1}) + MSO (1% vv^{-1}), applied alone and in combination with atrazine was included. Herbicide applications were made at two application timings, when Palmer amaranth was eight and 15 cm tall. Evaluations for weed control were made at seven and 21 days after treatment (DAT), and weed biomass was harvested at the conclusion of the experiment. Weed height and the addition of atrazine to the HPPD inhibitors influenced Palmer amaranth control. Palmer amaranth control and biomass reduction were greater when applications were made to eight cm tall Palmer amaranth. The addition of atrazine to mesotrione and topramezone increased Palmer amaranth control at the eight cm timing. Atrazine combinations with mesotrione, tembotrione, and topramezone were the only treatments that provided greater than 90% Palmer amaranth control for the 8 cm timing 21 DAT. There was a 30% increase in Palmer amaranth control when atrazine was added to mesotrione and tembotrione and applied at the 15 cm timing. The only HPPD inhibitor to demonstrate a synergistic relationship with atrazine was topramezone at the eight cm timing. Other HPPD inhibitor and atrazine combinations were additive in the field, regardless of application timing. The optimal timing for Palmer amaranth control with many of the HPPD-inhibiting herbicides applied with atrazine is eight cm. This research also demonstrates a differential response of Palmer amaranth to the different HPPD-inhibiting herbicides. Further research is needed to understand the relationship between atrazine and the HPPD inhibitors on this multiple-resistant population.

PALMER AMARANTH (*AMARANTHUS PALMERI*) CONTROL WITH SOIL-APPLIED HERBICIDE PROGRAMS WHICH CONTAIN DICAMBA, ISOXAFLUTOLE, AND 2,4-D. Douglas J. Spaunhorst*[1], Bryan G. Young[2], William G. Johnson[2]; [1]Purdue, West Lafayette, IN, [2]Purdue University, West Lafayette, IN (140)

Glyphosate-resistant (GR) Palmer amaranth (*Amaranthus palmeri*) prevalence in Midwest soybean (*Glycine max* L.) production has increased in recent years. New soybean herbicide-resistant traits will be important management tools for herbicide-resistant weeds. The objectives of this research were to evaluate preemergence (PRE) herbicide treatments that contain dicamba, isoxaflutole, metribuzin, *S*-metolachlor, and 2,4-D for GR Palmer amaranth control. Treatments containing either dicamba or isoxaflutole resulted in up to 37% greater Palmer amaranth control, up to 75 fewer leaves/plant, and up to 131 g less biomass accumulation than treatments with 2,4-D at 42 d after PRE treatment (DAPT). Mixing metribuzin and *S*-metolachlor with dicamba, isoxaflutole, or 2,4-D resulted in up to 55% greater control, up to 81 fewer leaves/plant, and up to 150 g less plant biomass when compared to PRE treatments with dicamba, isoxaflutole, or 2,4-D alone at 42 DAPT. Co-application of metribuzin with dicamba, isoxaflutole, or 2,4-D resulted in 67 to 72% control, while mixtures of *S*-metolachlor with dicamba, isoxaflutole, or 2,4-D provided 63 to 91% Palmer amaranth control.

FITNESS COSTS OF HERBICIDE RESISTANCE TRAITS IN WATERHEMP. Chenxi Wu*[1], Patrick Tranel[2], Adam S. Davis[3]; [1]University of Illinois at Champaign-Urbana, Urbana, IL, [2]University of Illinois, Urbana, IL, [3]USDA-ARS, Urbana, IL (141)

Fitness costs of herbicide resistance in the absence of herbicide selection play key roles in the evolutionary trajectory of herbicide resistance and serve as the theoretical basis for herbicide rotation, one of the most widely practiced herbicide-resistance mitigation strategies. Despite the importance of fitness costs to herbicide-resistance evolution, the acquisition of fitness cost information is surprisingly challenging due to the lack of robust short-term study systems. Therefore, a three-year multigenerational greenhouse study was conducted to determine the fitness costs of five herbicide resistances in common waterhemp. In the study, a synthetic waterhemp population was created by bulk crossing parental plants that collectively contained five types of herbicide resistances. The resulting progeny, which are segregating for the five different herbicide resistances, were subjected to competitive growth conditions in the absence of herbicide selection for six generations. The frequencies of the different resistant traits were determined at each generation from both whole-plant herbicide treatments (glyphosate, atrazine, HPPD inhibitors) and molecular markers (ALS and PPO inhibitors). Our results indicate that all of the resistance traits have little or no fitness costs. The frequency of plants that carry at least one resistance trait stayed the same after six generations across three replicate greenhouse rooms. The results from this novel fitness study indicate that herbicide rotation will not be a particularly effective resistance mitigation strategy.

DISCRIMINATING BOB FROM SUE: GENDER MARKERS FOR WATERHEMP. Ahmed Sadeque*[1], Patrick Brown[2], Patrick Tranel[1]; [1]University of Illinois, Urbana, IL, [2]University of Illinois Urbana-Champaign, Urbana, IL (142)

Evolution of multiple herbicide resistance in waterhemp poses a huge threat to the agricultural community. One of the characteristics aiding waterhemp in evolving resistance is its dioecious nature. The genetics and evolution underlying this dioecious nature of the plant are still not understood. In current work we are utilizing Restriction-site Associated DNA sequencing (RAD-seq) to gain insights into the sex-determination mechanism in waterhemp. Approximately 200 plants each of males and females were sampled and used to make RAD-seq libraries. Libraries were separately barcoded and then sequenced using the Illumina platform. Sequence data were analyzed with TASSEL (Trait Analysis by aSSociation, Evolution and Linkage) with a goal of identifying gender-specific reads. Through the analysis pipeline approximately one million reads were obtained. Further analysis of the sequence data was carried out through Python and R, which helped in identifying male- and female-specific reads. When sequence reads were evaluated with the criteria of being present at least 500 times in one sex and no more than two times in the other sex, 22 and 0 male- and female-specific reads, respectively, were identified. Some of the candidate male-specific reads were selected and PCR primers were developed for these candidate sequences. The PCR markers were then evaluated for gender specificity using nine waterhemp populations from four states. Six of the markers consistently distinguished male from female plants. The markers also consistently distinguished males from females in a hybrid population derived from smooth pigweed crossed with male waterhemp. In the long term, this research will provide tools to begin detailed investigations of the molecular biology and evolution of dioecy in *Amaranthus*. Ultimately, manipulation of gender expression in waterhemp could provide a novel weed management strategy.

PROFILING SAFENER-RESPONSIVE GST EXPRESSION IN GRAIN SORGHUM LINES THAT DIFFER IN S-METOLACHLOR TOLERANCE. Loren V. Goodrich*, Rong Ma, Patrick Brown, Dean E. Riechers; University of Illinois Urbana-Champaign, Urbana, IL (143)

Herbicide safeners are non-toxic compounds that confer protection to cereal crops by inducing detoxification and defense systems, including massive increases in the expression and activity of glutathione *S*-transferases (GSTs) and cytochrome P450s, although the precise molecular mechanisms for induction of expression remain unknown. In preliminary research, a genome-wide association (GWAS) study was conducted in the greenhouse with preemergence *s*-metolachlor, plus or minus the safener fluxofenim as a seed treatment, to determine phenotypes for natural herbicide tolerance and herbicide-safener responses in 400 diverse sorghum inbred lines. The top GWAS hit for safener response (plus/minus safener) was located on chromosome 9 or on chromosome 3 for herbicide sensitivity (plus/minus herbicide, with or without safener), with both hits in close proximity to *GST* gene clusters. Interestingly, preliminary RNAseq studies had identified specific GSTs genes that are highly induced by safener treatment, and each specific GST is located within these two gene clusters. Through an association panel screening of these 400 lines, two phenotypically diverse sorghum inbreds were identified; one displaying high natural tolerance to *s*-metolachlor (without safener) and one showing high sensitivity to *s*-metolachlor (with or without safener). Our objective was to quantify transcript levels of these two candidate *SbGSTs* in coleoptile tissue during a time-course analysis by utilizing reverse-transcriptase (RT)-PCR and gene-specific primers (GSPs) designed from each *GST* gene. Three sorghum lines were examined, which included the two sorghum inbreds differing in phenotype identified above through GWAS, and inbred BTx623, from which the sorghum genome was sequenced. Our hypothesis is that expression of either or both *SbGST* genes will correlate with natural or safener-enhanced herbicide responses to *s*-metolachlor in these three sorghum genotypes. Results showed a strong correlation between phenotype and basal expression of the *SbGST* on chromosome 9 at eight hrs after treatment (HAT), while no correlation was observed between phenotype and basal expression of the *SbGST* on chromosome 3 at eight HAT. Future experiments will examine basal and safener-induced expression of the *SbGSTs* using quantitative RT-PCR during a time course of four to 12 HAT to investigate further correlations. Identifying signaling and/or metabolic genes that play a major role in safener induction of endogenous detoxification pathways will provide opportunities to rapidly screen sorghum lines for increased herbicide tolerance, and to enhance abiotic stress tolerance in sorghum and other agricultural plants.

INFLUENCE OF HORSEWEED (*CONYZA CANADENSIS*) HEIGHT ON THE EFFICACY OF HALAUXIFEN-METHYL, DICAMBA, AND 2,4-D. Cara L. McCauley*[1], Bryan Young[2]; [1]Purdue University, Lafayette, IN, [2]Purdue University, West Layfette, IN (144)

Synthetic auxin herbicides are used to control broadleaf weeds in residential landscapes, rights-of-ways, and production agriculture. The auxin herbicides 2,4-D and dicamba are commonly used for management of glyphosate-resistant horseweed (*Conyza canadensis*) populations. Halauxifen-methyl is a new arylpicolinate auxin herbicide and is currently under development for use prior to planting corn or soybean for management of horseweed and other broadleaf species. Field experiments were conducted at two field sites to investigate the influence of horseweed height on the efficacy of 2,4-D, dicamba, and halauxifen-methyl. Twelve horseweed plants ranging from 5 to 30 cm tall were marked in each plot and heights were recorded at the time of herbicide application. Herbicide applications included halauxifen-methyl (2.5, 5, 10 g ae ha^{-1}), dicamba (140, 280, and 560 g ae ha^{-1}), and 2,4-D (280, 560, and 1120 g ae ha^{-1}) which represents an approximate 1/2X, 1X, and 2X of the typical field use rate for each of the herbicides. In addition, glyphosate was combined with each of the auxin herbicides at the 1X rate. Visual estimates of control for each of the marked plants were recorded at 7, 14, 21, and 28 d after treatment (DAT); plants were harvested at 28 DAT for dry weight determination. Across the different rates and locations, halauxifen-methyl and dicamba were equally efficacious, but 2,4-D had reduced efficacy comparatively. The 1X rate of halauxifen-methyl and dicamba achieved greater than 90% control at 28 DAT on horseweed up to 18 cm in height. Conversely, the 1X rate of 2,4-D did not achieve 90% control at any weed height. Halauxifen-methyl had the least amount of variability in horseweed control across the two field locations which suggests less of an influence of environmental conditions on halauxifen-methyl compared with dicamba and 2,4-D. The addition of glyphosate to the 1X rate of dicamba and halauxifen-methyl had no effect compared to the 1X rate of the auxin alone, likely due to the high degree of herbicide efficacy achieved from these herbicides. To the contrary, the addition of glyphosate to 2,4-D did enhance control of horseweed compared with 2,4-D applied alone. In summary, the efficacy of halauxifen-methyl on horseweed is similar to dicamba in terms of weed size yet may be more consistent under different environmental conditions. Future research is justified to validate these observations across different environmental conditions (i.e. temperature).

RESPONSE OF ABC- AND CATIONIC AMINO ACID-TRANSPORTERS GENES TO HERBICIDE STRESS IN *CONYZA* SP. PLANTS RESISTANT TO GLYPHOSATE AND PARAQUAT. Marcelo L. Moretti*[1], Rocio Alarcon-Reverte[2], Sarah Morran[2], Bradley D. Hanson[3]; [1]University of California, West Lafayette, CA, [2]University of California, Davis, CA, [3]University of California Cooperative Extension, Davis, CA (145)

Conyza bonariensis and *C. canadensis* are well-adapted to the tree nut cropping systems of California and are becoming increasing management challenges due herbicide resistance. Although glyphosate-resistant populations are known to be widespread, glyphosate-paraquat-resistant (GPR) populations have been more recently documented in the state. The mechanism of resistance of these GPR biotypes appears to be related to reduced translocation of glyphosate as well as paraquat. Previous research in *Conyza* sp. has associated ATP binding cassette (ABC) transporters with glyphosate-resistance and cationic amino acid transporters (CAT) with paraquat resistance. The current work use real-time PCR to evalaute the transcription response the glyphosate target enzyme EPSPS and the putative tonoplast transporters, ABC transporters (M10 and M11), CAT (CAT2 and CAT4) in response to glyphosate or paraquat treatment. Three biotypes of each species were selected for the study, glyphosate-paraquat-susceptible (GPS), glyphosate-resistant (GR), and GPR. Plants treated with glyphosate and paraquat were evaluated 24 and six hrs after treatment, respectively. Eight reference genes were evaluated for stability in response to glyphosate and paraquat, using NormFinder and BestKeeper software, and three genes were selected as reference genes (actin, rotamase-cyclophilin 5, and heat shock protein 70). GR and GPR *C. bonariensis* had an increase in the expression (>18-fold) of M10 and all biotypes had an increase in M11 (>7-fold) expression. In *C. canadensis*, both ABC transporters (M10 and M11) were induced by glyphosate in all biotypes by 5-fold or more. When treated with paraquat, *C. bonariensis* biotypes had an induction in both ABC transporters (>2.2-fold). In contrast, paraquat induced only the M10 transporter in GPS *C. canadensis*. No changes in expression were observed in any of the CAT transporters or EPSPS regardless of the herbicide treatment, species or biotype evaluated. In summary, this study indicates that up regulation of the ABC transporters (M10 and M11) are not clearly associated with glyphosate or paraquat resistance in the evaluated biotypes of Conyza sp., but rather these responses appear to be associated abiotic stress response. EPSPS or CAT transporters did not appear to be involved in glyphosate or paraquat resistance in *Conyza* sp. in this study.

CORRELATION OF INITIAL HERBICIDE SYMPTOMOLOGY WITH FINAL PARAQUAT EFFICACY ON MULTIPLE WEED SPECIES. Garth W. Duncan*[1], Julie M. Young[2], Bryan Young[3]; [1]Purdue University, Lafayette, IN, [2]Purdue University, West Lafayette, IN, [3]Purdue University, West Layfette, IN (146)

Effective burndown herbicides for control of herbicide-resistant weeds in no-till crop production are limited. Paraquat is an option to control a broad spectrum of weeds, but has demonstrated inconsistent control of some weed species such as horseweed. Variability in weed control with paraquat may be attributed to rapid desiccation leading to plant regrowth and inadequate control. The relationship between initial herbicide symptomology and final efficacy for weed control is unclear. Therefore, experiments were conducted to determine the relative efficacy of paraquat on select problematic weed species (Palmer amaranth, waterhemp, giant ragweed, horseweed, and purple deadnettle) and determine if initial symptomology may be an indicator of final efficacy. Treatments encompassed eight rates of paraquat (0, 1.10, 2.19, 4.38, 8.75, 17.5, 35, 70, 140 g ai ha^{-1}) with nonionic surfactant (NIS) at 0.25% v/v. Herbicide treatments were applied at 7:30 am on a day with full sun. Immediately following herbicide application, plants were returned to the greenhouse and placed under a 600W HPS light to promote herbicide activity. Visual estimates of wilting or necrosis were taken at 2, 4, 6, 8, 12, 24, 48, 72 hours after treatment (HAT) and 7 and 14 d after treatment (DAT) to capture initial symptomology and regrowth. Likewise, visual estimates for overall control were taken at 0.5, 1, 2, 3, 7, and 14 DAT. Plants were harvested at 14 DAT for dry weight determination. Sensitivity to paraquat was evaluated using a log-logistic model to determine the rate providing 50% growth reduction (GR_{50}). Visual ratings were correlated to the final percent dry weight of the control to evaluate predictability of control from visual assessment. Palmer amaranth and waterhemp were the most susceptible species to paraquat with GR_{50} values of 11 and 8.4 g ha^{-1}, respectively. Giant ragweed, horseweed, and purple deadnettle were more tolerant to paraquat with GR_{50} values of 21, 30, and 39 g ha^{-1}, respectively. Symptomology from the highest rates of paraquat evaluated was first observed at two HAT in Palmer amaranth, waterhemp, and giant ragweed, four HAT in purple deadnettle, and six HAT in horseweed. Correlation of visual control ratings with dry weight values indicated that visual control two DAT could accurately predict dry weight of waterhemp, horseweed, giant ragweed, and purple deadnettle ($p=0.05$) for the highest rate of paraquat evaluated. However, Palmer amaranth dry weight could not be accurately predicted based on dry weight correlation with any of the visual control ratings. This may be attributed to variability in initial control and eventually regrowth of Palmer amaranth treated with paraquat.

CONTINUED CHALLENGE TO CONTROL WATERHEMP IN SUGARBEET. Thomas J. Peters*, Andrew B. Lueck; North Dakota State University, Fargo, ND (147)

Field experiments were conducted near Herman, Lake Lillian and Moorhead, MN to evaluate waterhemp control from herbicides applied preemergence, lay-by (postemergence to sugarbeet, premergence to weeds) and postemergence in sugarbeet in 2015. These data were combined with data from 2014 to continue to refine recommendations for waterhemp control in sugarbeet. The goal is to develop a systems approach that combines residual and postemergence herbicides for season-long weed control. A locally adapted sugarbeet variety was planted 1-inch deep in 22-inch rows at each location. Preemergence herbicides were applied to appropriate plots immediately after planting. Two or three sequential postemergence applications were made at approximately 14-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 was evaluated at each postemergence application and waterhemp control was evaluated at the end of season. Data from 2015 experiments complimented data collected in 2014 since sugarbeet planting occurred in April and early May in 2015 whereas most experiments were planted in May and early June in 2014. Postemergence herbicides alone or in mixtures were applied on 232% of commercial sugarbeet acreage in Minnesota and North Dakota in 2014. However, postemergence herbicides did not provide adequate waterhemp control across experiments and years (environments). Glyphosate, which was applied on 228% of commercial sugarbeet acreage, provided only 46% waterhemp control when averaged across four environments in 2014 and 2015. Adding ethofumesate plus desmedipham & phenmedipham, ethofumesate plus triflusulfuron or desmedipham & phenmedipham plus triflusulfron with sequential applications of glyphosate improved control 32%, 30% or 26%, respectively.Herbicides applied preplant incorporated or preemergence and followed by glyphosate did not provide season-long waterhemp control in 2015 presumably since sugarbeet planting was earlier than in 2014. S-metolachlor at 0.48 and 0.71 lb/A and followed by two or three sequential glyphosate applications gave 61% and 68% waterhemp control, respectively, in 2015. Control from the same herbicides was 89% and 94%, respectively, in 2014. Herbicides applied lay-by with glyphosate plus ethofumesate and followed by glyphosate provided consistent waterhemp control across experiments and years. Glyphosate at 0.98 fb 0.98 fb 0.77 lb ae/A plus ethofumesate at 0.13 lb/a in each glyphosate tank-mixture averaged 70% waterhemp control across three environments. Addition of S-metolachlor, acetochlor or dimethenamid-P improved waterhemp control, averaging 90%, 89% and 92%, respectively, across environments. However, waterhemp control from lay-by applications was dependent on several factors including sugarbeet planting date, precipitation to activate residual herbicides, and intensity of waterhemp infestation which contributed to experiment-by-experiment variation. An area to investigate in future research is residual herbicides applied preemergence and followed by residual herbicides applied lay-by. Experiments conducted in 2015 suggest that stratification of soil-applied herbicides will improve the consistency of waterhemp control in sugarbeet.

EDAMAME (*GLYCINE MAX*) CULTIVAR TOLERANCE TO PYROXASULFONE. Nicholas E. Hausman*, James Moody, Martin Williams II; USDA, Champaign-Urbana, IL (148)

Pyroxasulfone controls several annual grass and broadleaf weeds which are currently problematic in edamame; however, the herbicide is not presently registered for use, in part, due to concern about sensitivity of the crop to pyroxasulfone. Field trials were conducted in 2014 and 2015 near Urbana, IL to determine edamame cultivar tolerance to pyroxasulfone applied preemergence (PRE) and early postemergence (EPOST). Using a split block design with three replications, two factors were examined in a factorial arrangement of treatments. Herbicide application was assigned to main plots, with levels of PRE, EPOST, and a non-treated control. Pyroxasulfone was applied at a 2x field use rate (417 g a.i. ha^{-1}) using a compressed-air backpack sprayer. Soybean cultivar was assigned to subplots, using several edamame cultivars plus two grain-type cultivars; specifically, Asgrow 3253 and Pioneer 93Y41. Response variables included seedling density one to three wks after planting (WAP), crop injury after herbicide application, and leaf area and plant biomass five WAP. Soybean cultivars responded similarly to pyroxasulfone, as evidenced by no interaction ($P \geq 0.732$) between cultivar and herbicide application for any response variable. Pyroxasulfone did not influence edamame establishment ($P=0.278$). Low levels of crop injury (<11%) after herbicide application were consistent with reduced early plant growth, as evidenced by 24 and 11% lower early plant biomass from PRE and EPOST applications, respectively, compared to the control. Nonetheless, edamame cultivars were no more sensitive to pyroxasulfone than the grain-type cultivars used in the study. Risk of injury to edamame from pyroxasulfone at a 2x field use rate is comparable to risk of injury to grain-type soybean. Given the limited herbicide options for use in edamame and high cost of handweeding, vegetable growers would likely consider this relatively low level of risk for crop injury.

HERBICIDE MANAGEMENT SYSTEMS TO CONTROL WEEDS IN COMMERCIAL EDAMAME PRODUCTION. James L. Moody*, Nicholas E. Hausman, Martin Williams II; USDA, Champaign-Urbana, IL (149)

Edamame, a specialty food-grade soybean popular among health-conscious consumers, is growing in popularity worldwide. Despite a well-developed soybean industry, most edamame consumed in the U.S. is imported from Asia. Considerable interest exists in growing edamame domestically, but however, weed interference is a major problem, and until recently, only a single herbicide was registered for use on the crop. The objectives of this work were (1) to compare effectiveness of weed management treatments that utilize herbicides currently registered for use on edamame or that may be registered in the near future, (2) to determine the significance of edamame cultivar on performance of these treatments, and (3) to identify potential relationships between the crop and weed. Ten different weed management treatments were tested in three edamame cultivars over a 3-yr period. Weed management treatments increased marketable pod yield relative to the nontreated control, but only treatments with saflufenacil or S-metolachlor combinations were comparable to the hand-weeded weed-free treatment. S-metolachlor followed by imazamox was among the greatest yielding, had the least weed density and biomass, and did not reduce crop population density. Also, cultivars differed in their weed-suppressive ability. Path analysis indicated certain relationships were consistent across cultivars, such as weed population density having a direct negative association with crop biomass. Other edamame–weed interactions were not identical across cultivars. Although more improvements are needed, the vegetable industry is beginning to have nascent weed management options in edamame, which will likely reduce reliance on hand weeding and result in crop-production costs that are more competitive in the global market.

POTATO RESPONSE TO SUBLETHAL DOSES OF GLYPHOSATE AND DICAMBA. Harlene M. Hatterman-Valenti*, Collin Auwarter; North Dakota State University, Fargo, ND (150)

Non-target injury from glyphosate drift to non-glyphosate-resistant crops has been a concern since the introduction of glyphosate-resistant crops. Research has shown the detrimental effects from glyphosate drift onto potatoes, especially when these plants are growing tubers that will be used for seed. Research has also shown significant injury to the current season potato crop when glyphosate drifts to the potato during the tuber initiation and early bulking stages. However, no information on the potential damage to potato from the drift of glyphosate + dicamba is available even though the combination should cause greater losses due to the high selective activity of dicamba on broadleaf plants. Three rates of glyphosate, dicamba, and glyphosate + dicamba were applied to 'Russet Burbank' plants at the tuber initiation stage at two locations. The southern location was planted three wk before the northern location. Even though herbicides were applied to potato during the tuber initiation stage, the degree of symptomology varied between locations with injury symptoms approximately three times more pronounce at the southern location. Injury to potato 20 d after application (DAA) at the southern location were greatest with the highest rate of glyphosate, but this did not difference from the application of the highest rate of glyphosate and dicamba. Little injury was observed from dicamba alone. At the northern location, little potato injury occurred regardless of the treatment. Current season yield indicated that yields were greater at the southern location than the northern location, but the treatment by location interaction was not significant. The greatest yield reduction compared to the untreated occurred with the highest dose of dicamba and the highest dose of glyphosate + dicamba, which was 18 and 7% of the untreated total yield, respectively.

SIMULATED GLYPHOSATE DRIFT IN RED NORLAND SEED POTATO FIELDS AFFECTS DAUGHTER TUBERS. Amanda Crook*; NDSU, Fargo, ND (151)

The North Dakota State Seed Department is the second largest seed potato program in the U.S. and is known for the production of high quality seed. This study was conducted at the NDSU research fields in Fargo, ND in 2015 to evaluate the effects of using Red Norland daughter tubers as seed from a mother plant that was exposed to glyphosate drift in the 2014 growing season. Glyphosate drift was simulated on the mother plants at 1/4, 1/8, 1/16, and 1/32 the standard use rate (840 g a.e. ha^{-1}) during three growth stages: tuber initiation (TI), early tuber bulking (EB) and late tuber bulking (LB). Daughter tubers were harvested after 93 d of growth and placed in cold storage for eight months before the standard cutting and planting procedures. Data were collected on emergence, vigor, plant height, yield, total tuber numbers, and tuber damage. A drastic decrease of emergence was observed when simulated drift was applied at EB or LB growth stages, except at the lowest rate, however plant vigor was compromised. Due to lack of emergence and plant vigor in EB and LB treatments, plant height, yield and total tuber numbers were affected. TI treatments were similar to untreated control.

CONTROL OF LINURON-RESISTANT PIGWEED IN CARROT. Darren E. Robinson*[1], Clarence Swanton[2]; [1]University of Guelph, Ridgetown, ON, [2]University of Guelph, Guelph, ON (152)

Expanding the availability of different herbicide modes-of-action to vegetable producers will help to minimize the frequency at which current modes-of-action are used and therefore will reduce the potential for the evolution of herbicide resistance. One useful strategy that can be adopted to reduce the evolution of resistance is tank-mixing herbicides with different modes-of-action. In addition, the sequential application of preemergence (PRE) and postemergence (POST) herbicides with different modes-of-action is another strategy that may help reduce the potential for resistance to evolve. The objective of this study was to evaluate tolerance of carrot grown on mineral and muck soils to various PRE and POST herbicides, and determine the best combination of herbicides with differing modes-of-action for control of linuron-resistant redroot and green pigweed (*Amaranthus* spp.). Tank-mixtures of s-metolachlor with ethofumesate or pendimethalin (PRE) followed by micro-rates of acifluorfen (applied twice at 18.75 g ai ha^{-1} to weeds at the cotyledon to 1-leaf stage) gave the best control of *Amaranthus* spp. as well as other common annual broadleaf and grass species commonly found in the carrot production area of southern Ontario. Visible injury was observed in those treatments where oxyfluorfen or fomesafen micro-rates followed the PRE tank-mixtures at seven days after application (DAA) of the POST herbicides. Though carrot outgrew this injury by 28 DAA, carrot yields were less than the untreated check where oxyfluorfen micro-rates were applied after a PRE herbicide treatment. Carrot yield was greatest where a PRE tank-mixture of s-metolachlor + ethofumesate + pendimethalin and POST micro-rate applications of acifluorfen were applied in sequence. The results of this research may be incorporated into a comprehensive Integrated Weed Management strategy that relies on multiple modes-of-action within a rotation, and can be enhanced by utilizing crop competitiveness and non-chemical weed control.

BICYCLOPYRONE PERFORMANCE IN MINOR/SPECIALTY CROPS. Cheryl L. Dunne*[1], Venance H. Lengkeek[2], Dain E. Bruns[3], Thomas H. Beckett[4], Gordon D. Vail[4]; [1]Syngenta, Vero Beach, FL, [2]Syngenta Crop Protection, St. Johns, MI, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta, Greensboro, NC (153)

Bicyclopyrone is a newly registered HPPD-inhibiting active ingredient for control of broadleaves and some grasses. Bicyclopyrone is one of the four active ingredients in Acuron herbicide which was registered for sales in corn in 2015. Syngenta is evaluating the potential for expanding bicyclopyrone use into minor/specialty crops where options for weed control are limited. More than 40 crops have been screened in the greenhouse and/or field for pre-emergence and postemergence tolerance to bicyclopyrone. The objective of this presentation is to present data onsome of the crops showing acceptable tolerance to bicyclopyrone.

HERBICIDE COMBINATIONS FOR WEED CONTROL IN FRUIT CROPS. Colin J. Phillippo*[1], Bernard H. Zandstra[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, Holt, MI (154)

Perennial tree crops present specific weed control challenges. The plantings are maintained for many years, leading to establishment of perennial weeds and certain annual weeds. Use of herbicides with the same mode-of-action (MOA) for many years results in a population of annual and perennial weeds that adapt to the weed control methods used. Common perennial weeds in tree fruit are quackgrass, orchardgrass, dandelion, goldenrod, horsenettle, and buckhorn plantain. Common annual and biennial weeds are common lambsquarters, common mallow, common ragweed, horseweed, pigweeds, white campion, wild carrot, large crabgrass, barnyardgrass, foxtails, and fall panicum. The most effective method for control of these weeds is to develop a weed management plan for use over several years. Each application should include two modes-of-action of residual herbicides + a foliar active herbicide. By applying herbicide combinations that include multiple MOA at specific times during the year most annual and perennial weeds can be controlled. Experiments were conducted to test various pre-mixture and tank mix combinations applied to apple in spring or fall. A pre-mixture of oxyfluorfen + penoxsulam (Pindar GT) + glyphosate was applied in spring or fall for three years. The combination gave almost 100% control of all weeds for 3 years. Fall and spring applications had similar weed control. It was more effective than oxyfluorfen + glyphosate. The addition of glyphosate was important for control of fall or early spring germinating weeds such as horseweed, dandelion, and white clover. A pre-mixture of sulfentrazone + carfentrazone (Zeus Prime XC) + diuron + glyphosate applied in early spring was effective in controlling most annual and perennial weeds. When applied in early spring and again in mid-season, it provided almost 100% weed control for the season. Zeus Prime XC + indaziflam + glyphosate followed by Zeus Prime XC + halosulfuron in mid-season was very effective for weed control. Other effective combinations were rimsulfuron + diuron, indaziflam + rimsulfuron + glyphosate, and flumioxazin + oryzalin + saflufenacil. In blueberry, effective herbicide combinations that provided almost total weed control through July were Zeus Prime XC + terbacil + glyphosate, Zeus Prime XC + indaziflam + glyphosate, Zeus Prime XC + diuron + glyphosate, and indaziflam + rimsulfuron + glyphosate.

DUPONT™ ZEST™ HERBICIDE: NEW GRASS CONTROL OPTION FOR INZEN™ SORGHUM. Jeffrey T. Krumm*[1], Kenneth L. Carlson[2], David W. Saunders[2], Robert N. Rupp[3], Bruce V. Steward[4], Keith D. Johnson[5]; [1]DuPont Crop Protection, Hastings, NE, [2]DuPont Crop Protection, Johnston, IA, [3]DuPont Crop Protection, Edmond, OK, [4]DuPont Crop Protection, Overland Park, KS, [5]DuPont Crop Protection, Grand Forks, ND (155)

No abstract submitted

WEED MANAGEMENT IN INZEN SORGHUM. Rodrigo Werle*, John L. Lindquist; University of Nebraska- Lincoln, Lincoln, NE (156)

Traditional breeding technology is currently being used to develop grain sorghum germplasm that will be tolerant to acetolactate synthase (ALS)-inhibiting herbicides. This technology (Inzen, DuPont) has the potential to improve sorghum production by allowing for the postemergence control of traditionally hard-to-control grasses in the U.S. Field studies conducted with Inzen sorghum across the US sorghum production area have shown satisfactory grass management with the postemergence application of nicosulfuron, and the sorghum producing community is highly interested in adopting the technology. Despite its' potential, there are concerns regarding the introduction of this technology. For instance, grain sorghum and weedy sorghum species (e.g., shattercane, johnsongrass) can interbreed, and introduced traits such as herbicide tolerance could increase the invasiveness of weedy relatives. Moreover, ALS-resistance in weedy sorghum populations and in other grass species has been reported, indicating that over-reliance on ALS-chemistry is likely to select for resistant biotypes. Over the last eight years of sorghum-shattercane research, our lab has found that their synchrony of flowering under field conditions is nearly complete, gene flow takes place at a significant rate, and that F1 hybrids are as fit as the wild parents. In field surveys, we found that ALS-resistance selected for more than a decade ago persists in wild populations, indicating the lack of a strong fitness cost associated to the ALS-resistance trait. Finally, our modeling efforts have demonstrated that in the presence of shattercane, evolution of resistance may occur rapidly if Inzen sorghum is planted continuously. The time for resistance evolution was predicted to decrease with increased cropping system complexity. Thus, crop and herbicide rotation will be key strategies to postpone the evolution of ALS-resistance in shattercane. With this presentation we intend to share a summary of our research over the past eight years and provide scientific information regarding the benefits and some of the concerns related to the upcoming herbicide-tolerant grain sorghum technology.

UTILIZING DICAMBA + TEMBOTRIONE FOR WEED CONTROL IN CORN. Mark A. Waddington*[1], Mark Wrucke[2], Kevin Watteyne[3]; [1]Bayer CropScience, RTP, NC, [2]Bayer CropScience, Minneapolis, MN, [3]Bayer CropScience, Lincoln, NE (157)

Diflexx Duo is a new postemergence herbicide developed by Bayer CropScience for use in corn. This product will be labelled in field corn, seed corn, popcorn, and corn grown for silage. Diflexx Duo is a pre-formulated mixture containing dicamba and tembotrione with the safener cyprosulfamide. Diflexx Duo is formulated with 1.26 and 0.27 pounds per gallon of dicamba and tembotrione, respectively. The broad spectrum grass and broadleaf activity allows use with or without glyphosate or glufosinate in common weed management systems. Diflexx Duo will be recommended up to V7, with a rate range of 24 – 40 fluid ounces per acre. The safety of Diflexx Duo allows this technology to be used with various adjuvants or other crop protection products being applied at this time. The wide application window, flexible use rate, liquid formulation, and multiple effective modes-of-action will ensure safe and effective weed control on tough to control weeds.

RESICORE™: A NEW CORN HERBICIDE FROM DOW AGROSCIENCES. Scott Ditmarsen*[1], Michael Moechnig[2], Mark Peterson[3], David Ruen[4], David Simpson[3], Chris Voglewede[3]; [1]Dow AgroSciences, Madison, WI, [2]Dow AgroSciences, Toronto, SD, [3]Dow AgroSciences, Indianapolis, IN, [4]Dow AgroSciences, Lanesboro, MN (158)

Dow AgroSciences has developed a new herbicide for broad spectrum weed control in corn. Resicore™ herbicide is a pre-mixture product containing the active ingredients acetochlor, mesotrione, and clopyralid in a novel suspoemulsion formulation for use in field corn, field seed corn, field silage corn, sweet corn, and yellow popcorn. With three effective modes-of-action, Resicore provides broad spectrum control of most annual grasses and broadleaf weeds, with up to eight weeks or more of soil residual activity. It can also be tank-mixed with atrazine, glyphosate, and other corn herbicides, which provides flexibility to combine additional modes-of-action in a single application. Resicore has a wide window of application, ranging from early preplant through postemergence when applied according to label directions. Results from over 50 Dow AgroSciences research trials conducted in 15 states across the corn belt from 2012-2015 have demonstrated excellent crop tolerance to Resicore and broad spectrum preemergence and postemergence control of many key weeds, including several difficult-to-control species and herbicide-resistant biotypes such as giant ragweed (*Ambrosia trifida*), morningglory (*Ipomoea spp*.), Palmer amaranth (*Amaranthus palmeri*), and common waterhemp (*Amaranthus rudis*). Resicore is an effective weed management tool and will play an important role in herbicide resistant weed control strategies and programs.

ACURON FLEXI: A NEW HERBICIDE FOR CORN. Ryan D. Lins*[1], Thomas H. Beckett[2], Gordon D. Vail[2]; [1]Syngenta, Rochester, MN, [2]Syngenta, Greensboro, NC (159)

Acuron Flexi is a new selective herbicide for weed control in field corn, seed corn, popcorn and sweet corn. Acuron Flexi contains mesotrione, S-metolachlor, and bicyclopyrone with anticipated first commercial applications in the 2016 growing season (upon receipt of necessary regulatory approvals). Between 2013 and 2015, field trials were conducted to evaluate Acuron Flexi for weed control and crop tolerance. Results show that Acuron Flexi very effectively controls many difficult weeds and provides improved residual control and consistency compared to other competitive products.

ACURON HERBICIDE: RAISING THE BAR FOR WEED CONTROL. Steven P. Mroczkiewicz*[1], Scott E. Cully[2], Thomas H. Beckett[3], Gordon D. Vail[3]; [1]Syngenta, Attica, IN, [2]Syngenta, Marion, IL, [3]Syngenta, Greensboro, NC (160)

Acuron is a new selective pre-mixture herbicide for weed control in field corn, seed corn, popcorn and sweet corn. Acuron contains the 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. Acuron is the first bicyclopyrone-containing product to be registered. It is a multiple mode-of-action herbicide pre-mixture that provides preemergence and postemergence grass and broadleaf weed control combining mesotrione, s-metolachlor, atrazine, and benoxacor with bicyclopyrone. Field trials were conducted to evaluate Acuron for burndown and residual weed control. Results show that Acuron will control many difficult weeds in no-till corn and provides improved residual control and consistency compared to other available commercial programs.

GLYPHOSATE-RESISTANT GIANT RAGWEED CONTROL IN CORN AND WHEAT. Peter H. Sikkema*, Nader Soltani; University of Guelph, Ridgetown, ON (161)

Eight field trials, four with preplant (PP) and four with postemergence (POST) herbicides in corn and four field trials in winter wheat were conducted from 2012 to 2014 on various Ontario farms infested with glyphosate-resistant giant ragweed to determine the efficacy of PP and POST tank-mixtureses in corn and POST herbicides in winter wheat. In corn, glyphosate tank-mixtures with atrazine, dicamba, dicamba + atrazine, mesotrione + atrazine, flumetsulam, isoxaflutole + atrazine, saflufenacil + dimethenamid-P, S-metolachlor+atrazine and rimsulfuron applied PP provided up to 54%, 95%, 93%, 95%, 40%, 89%, 91%, 50% and 93% control of GR giant ragweed and reduced dry weight 69%, 100%, 99%, 100%, 30%, 92%, 98%, 66% and 99%, respectively. Additionally, POST application of glyphosate alone and tank-mixtures with 2,4-D ester, atrazine, dicamba, dicamba + diflufenzopyr, dicamba + atrazine, bromoxynil + atrazine, prosulfuron + dicamba, mesotrione + atrazine, topramezone + atrazine, tembotrione + thiencarbazone-methyl and glufosinate provided up to 31%, 84%, 39%, 94%, 89%, 86%, 83%, 78%, 72%, 43%, 63% and 58% control of GR giant ragweed and reduced dry weight 55%, 99%, 72%, 99%, 99%, 98%, 96%, 96%, 93%, 89%, 91% and 95%, respectively. In winter wheat, the herbicide evaluated provided 54 to 90% and 51 to 97% control of GR giant ragweed at four and eight weeks after treatment, respectively. Reductions in GR giant ragweed population density and dry weight were 62 to 100% and 83 to 100%, respectively and generally reflected the level of control.

SURVEY OF MULTIPLE HERBICIDE RESISTANCE IN CENTRAL KANSAS PALMER AMARANTH. Jennifer Jester*, Philip W. Stahlman; Kansas State University, Hays, KS (162)

To screen Palmer amaranth populations for resistance to glyphosate, seed was collected in fall 2014 from 40 ± 5 Palmer amaranth plants in each of 157 fields in 24 southcentral and northwestern Kansas counties and composited into one sample per field after drying and cleaning. Seed was placed in cold storage (0 C) for approximately three months and then moved to storage at room temperature. In spring 2015, each population was seeded into 10 by 10 cm plastic pots filled with commercial potting mix. When approximately 6- to 9-cm tall, plants were sprayed with a dose of 870 g ha^{-1} glyphosate and 1% w/v ammonium sulfate. At 7 days after spraying, the number of both living and dead plants were counted. Each pot contained a minimum of 10 plants. Of the 157 populations, all plants of 48 populations were susceptible to glyphosate and all plants of 55 populations were resistant, while 54 populations were segregating for glyphosate resistance. The ratio of R:S plants in segregating populations varied widely from mostly resistant to mostly susceptible. Four populations from each of nine counties are being tested further for resistance to chlorsulfuron, dicamba, 2,4-D, and glyphosate plus 2,4-D. Those trials are still ongoing but differential response among the populations is apparent.

MOLECULAR APPROACHES TO STUDY HERBICIDE-RESISTANT WEEDS.Â . Patrick Tranel*; University of Illinois, Urbana, IL (163)

A variety of DNA-based approaches are now commonly used to assist in investigations of herbicide-resistant weeds. In particular, molecular approaches to investigate target-site-based herbicide resistances are well established. DNA sequences of target-site genes are now readily available for many weed species, and there are databases that catalog resistance-conferring target-site mutations identified to date in various weeds. Consequently, it usually is relatively straightforward for a minimally equipped molecular biology lab to determine if a mutation in a herbicide target-site gene is responsible for resistance in a given weed biotype. Several molecular marker systems, which range in their use of simple gel electrophoreses to somewhat more sophisticated quantitative PCR procedures, are available to facilitate high-throughput screening of multiple plants or populations for specific resistance mutations. Molecular investigations of nontarget-site (NTS) herbicide resistances are still in their infancy, but recent progress has been made. In particular, transcriptomic approaches, which compare expression patterns of thousands of genes, are being used to identify genes contributing to NTS resistance. Whether investigating target-site or NTS resistance, it is key to have appropriate genetic material from the weed population of interest. For example, co-segregation analysis is a very powerful approach to determine if a particular gene is actually contributing to a resistance phenotype.

RNASEQ: A METHOD FOR UNDERSTANDING SIGNALING AND RESPONSES OF WEEDS TO VARIOUS STRESSES AND THEIR IMPACT ON CROPS. David Horvath*[1], Dasheng Liu[2], Sharon Clay[3], Munevver Dogramaci[1], Michael Foley[1], Wun Chao[1], James Anderson[1]; [1]USDA-ARS-RRVARC, Fargo, ND, [2]Shandong Institute of Environmental Science, Jinan, Peoples Republic, [3]South Dakota State University, Brookings, SD (164)

Weeds respond to stresses and interact with crops by sensing their environment and responding to it by altering their structure and or physiology to their best advantage. The initial step in altering their structure and/or physiology is changing the expression of the genes encoding proteins required to adapt to their environment. Changes in gene expression can be calculated through sequencing samples of messenger RNA from plants experiencing changes in their environment and counting the number of times any given RNA is sequenced in the sample. This technique is commonly referred to as RNAseq. Recent advances in sequencing technology that have greatly reduced the cost of sequencing, and innovative and relatively easily accessible bio-informatics programs have opened up any weed to RNAseq analysis. We have used this technique to gain an understanding of differences in the aquatic invasive plant alligatorweed (*Alternanthera philoxeroides*) that have recently evolved to allow this species to expand its range farther into Northern China than was predicted by previous models. This work identified several genes and physiological alterations, including a capacity to reduce photosynthesis in the cold that have allowed alligatorweed to survive in colder temperatures. Additionally, we have used this technique to examine how weeds are detected by crop plants such as corn (*Zea mays*) and soybeans (*Glycine max*), and how they identified components of the signaling network in those crops that might be manipulated to make them less weed responsive and thus potentially grow better even when weeds are present. We have even used this technique to follow the developmental differences in the buds of leafy spurge (*Euphorbia esula*) following dormancy transitions and after treatment with glyphosate. This powerful technique can now be used to understand all manners of responses of weeds to their environment or during different stages of their growth and development.

MOLECULAR TECHNIQUES: TRANSITIONING FROM GRADUATE STUDENT THEORY TO REAL-WORLD APPLICATIONS. R. Joseph Wuerffel*[1], Matthew Cutulle[2]; [1]Syngenta Crop Protection, St. Louis, MO, [2]Syngenta Crop Protection, Vero Beach, FL (165)

Weed science graduate students frequently implement applied field or greenhouse research to provide practical weed management solutions to growers. Following graduation, many weed science students pursue industry careers where they are often expected to utilize applied skills in some capacity. Fewer graduates are hired into academic positions, where in many cases weed management solutions are researched and publicized to growers. In a general sense, many weed science graduate students in the North Central region are trained in applied field research in preparation for the aforementioned career paths. Molecular techniques have been less widely adopted; however, the adoption of these techniques has increased with challenges of herbicide resistance and the need to develop new technology to overcome these weed management challenges. Graduate student projects and coursework reflect the need to address these challenges as a greater number of weed science projects incorporate molecular techniques. While molecular techniques and coursework in molecular biology unambiguously enhance the scientific fortitude of the graduate student and their thesis project, one might ask if these techniques are worthwhile when the majority of students enter a career field that often requires an applied skill-set. To address the latter, this presentation makes the case that molecular theory has practical applications and will provide valuable experience, regardless of the career path of the graduate student.

INFERRING THE EVOLUTION AND SPREAD OF AGRICULTURAL WEEDS AND INVASIVE PLANTS USING MOLECULAR TOOLS. Marie Jasieniuk*; University of California-Davis, Davis, CA (166)

No abstract submitted

INTRODUCTION AND SPREAD OF GLYPHOSATE-RESISTANT PALMER AMARANTH AND WATERHEMP ACROSS KENTUCKY - THE PAST FIVE YEARS. JD Green*[1], James R. Martin[2]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY (167)

The presence of Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus* [syn *rudis*]) was limited except for a few localized areas of west Kentucky prior to the year 2000. Between 2005 and 2010 isolated problems with control of these Amaranthus species with glyphosate in grain crops began to develop and were reported in counties in west Kentucky adjacent to major rivers including the Mississippi, Ohio, Cumberland, and Green Rivers. Several county Extension agents reported that infestations of these pigweeds often occurred in fields within the floodplains. It was thought that excessive flooding caused a rapid spread of both Amaranthus species on bottomlands but weed seed was also spread on some upland areas with equipment, especially combines and other equipment used at harvest. In 2010 Palmer Amaranth was reported in eight west Kentucky counties and waterhemp in five counties. Based on a county agent survey during 2011 Palmer amaranth and waterhemp were reported in 17 and 11 counties, respectively, and populations were not effectively controlled by glyphosate. In 2012 leaf samples were collected in 17 counties to analyze for resistance to glyphosate and other herbicides. These results indicated that most of the plants which had spread across the state were introduced from seed sources that were already genetically resistant to glyphosate. By 2013 Palmer amaranth began to spread eastward across the state and was present in 24 counties, including two observations near central Kentucky. Waterhemp was still mostly observed in 10 counties that bordered the lower Ohio River, but was also present in four counties along the upper Ohio River between Louisville and Cincinnati. A survey of county Extension agents in 2015 confirmed glypohsate-resistant Palmer amaranth is present in at least 50 counties that extend from west Kentucky eastward to counties within the central parts of Kentucky including three counties northeast of Lexington. Glyphosate-resistant waterhemp is not as widespread but now occupies nearly 30 counties that include counties that border the lower and upper Ohio River but also several isolated counties throughout the state. In addition to glyphosate-resistant Palmer amaranth and waterhemp, there was evidence in 2012 indicating ALS-resistance was present in some populations of both species in Kentucky. Results this summer using DNA analysis indicate PPO-resistant Palmer amaranth and waterhemp are also present in Kentucky. A variety of sources is thought to have contributed to the introduction of Palmer amaranth and waterhemp across Kentucky. A primary source is equipment used in the production and harvest of crops. Another known source of Palmer amaranth seed is through cotton seed hulls fed to cattle and the subsequent manure spread onto cropland. Other sources include contamination in cover crop seed as well as birds and other animals. The spread of populations with multiple herbicide resistance, especially cases involving PPO inhibitors, will create new and significant challenges in managing Palmer amaranth and waterhemp.

OCCURRENCE OF COMMON MILKWEED IN IOWA AGRICUTURAL LAND. Bob Hartzler*, Sydney Lizotte-Hall; Iowa State University, Ames, IA (168)

The monarch butterfly depends on members of the milkweed family for oviposition and larval development. Monarch populations have declined by more than 90% in the past twenty years. The decline is attributed to several factors, including loss of overwintering habitat in Mexico and loss of milkweed in its summer breeding region. The majority of the migrating generation of monarchs are born in Iowa and surrounding states, thus this region is critical for the insect. The U.S. Fish and Wildlife Service has been petitioned to list the monarch under the Endangered Species Act. The College of Agriculture and Life Sciences at Iowa State University initiated the Iowa Monarch Conservation Consortium (IMCC) in 2015 to lead a science-based approach to enhance monarch reproduction in Iowa. The focus of the IMCC is to support monarch habitat improvement in underutilized areas of rural landscapes that do not conflict with agricultural production. A survey of Iowa corn and soybean fields and adjacent roadsides was conducted in 2015 to establish a baseline of milkweed in the Iowa landscape; similar surveys were conducted in 1999 and 2009. The percentage of roadsides with common milkweed present increased slightly in the period covered by the surveys (71% in 1999 compared to 85% of roadsides in 2015). The percent of crop fields with common milkweed declined from 51% in 1999 to 7% in 2009, and the amount of common milkweed in infested fields declined by more than 90%. The widespread use of glyphosate is believed to have contributed to the decline. In 2015, common milkweed was found in 38% of crop fields, and the area of common milkweed increased from 5 m^2 ha^{-1} in 2009 to 18 m^2 ha^{-1} in 2015. Possible reasons for the increase in common milkweed between 2009 and 2015 include differences in early-season growing conditions between the two years and adaptation of common milkweed to current production practices. Twenty-five fields enrolled in the Conservation Reserve Program (CRP) were surveyed in the summer of 2015 for the presence of milkweed. Common milkweed was present in 88% of CRP fields. The average density was 493 stems per hectare. Common milkweed was the dominant species in CRP fields, but *Asclepias sullivanti* (prairie milkweed) was present in 15% of the fields. *Asclepias verticillata (*whorled milkweed) was observed in one CRP field. Future activities of the IMCC will include investigation of factors that influence utilization of *Asclepias* by monarch butterflies (e.g. preference in *Asclepias* species, patch density, landscape position) and development of cost effective methods of establishing monarch habitat.

PALMER AMARANTH EDUCATION, ARE WE LOSING THE BATTLE? Curtis R. Thompson*; Kansas State University, Manhattan, KS (169)

Palmer amaranth (AMAPA) has been documented resistant to several classes of herbicides in Kansas. In 1993 AMAPA was reported resistant to imazethapyr. In 1995 is was reported resistant to atrazine. In 2009 AMAPA was reported multiple resistant to ALS, triazines, and HPPD inhibitors. In 2011, AMAPA was reported resistant to glyphosate. Education of AMAPA management in field crops has focused on the use of herbicides with multiple modes-of-action or tank-mixtures of herbicides with different modes-of-action. There has been a significant emphasis encouraging growers to use preemergence herbicides. A plethora of research shows controlling AMAPA before it emerges has been a successful part of a total weed control program in all crops grown in KS! This has been reinforced by the lack of adequate control with POST only treatments in sorghum and soybean. Two pass systems, preemergence followed by post herbicides has been most effective. The potential stumbling block to adoption of a two pass system is the cost of the herbicide program. Glyphosate resistance, initially documented in southcentral, KS and in the Kansas River Valley, has increased to epidemic levels throughout central Kansas and now moving out to western Kansas. The frequency of calls from growers and growers concerns at educational meetings and tours suggests the problem is growing rapidly. No-till producers are considering early pre applied herbicides and overlapping residuals to help manage the early and multiple flushes of AMAPA. Hand weeding crews have been hired in some instances, however, only marginal success had been reported. Cost of weed control programs has increased significantly because of glyphosate resistant Palmer amaranth. It's only a matter of time and Palmer populations resistant to glyphosate, HPPD inhibitors, ALS inhibitors, and triazines will be discovered. At what point do we refocus our efforts as the educators and growers did in the SE U.S., and take the approach of zero tolerance for AMAPA?

WEEDS WEEK: HERBICIDE RESISTANT WEED MANAGEMENT EDUCATION IN IOWA. Virgil Schmitt[1], Robert Hartzler[2], Meaghan Anderson*[3], Angela Rieck-Hinz[4], Paul Kassel[5], Micheal Owen[2], Terrance Basol[6], Brent Pringnitz[2]; [1]Iowa State University, Muscatine, IA, [2]Iowa State University, Ames, IA, [3]Iowa State University, Iowa City, IA, [4]Iowa State University, Clarion, IA, [5]Iowa State University, Spencer, IA, [6]Iowa State University, Nashua, IA (170)

Due to the prevalence of herbicide-resistant weeds in Iowa, farmers and crop advisors must be well-versed in herbicides, sites-of-action, and effectiveness of herbicides against target weeds. As part of a plan to further educate on herbicide resistance in Iowa, Iowa State University Extension field agronomists and campus faculty developed and presented a "Weeds Week" educational program at five ISU research farms located across Iowa. The program focused on improving the knowledge base of farmers and their crop advisors on the current status of herbicide resistance in Iowa and herbicides by group number classification. The goal of the training was for attendees to be able to design weed management programs that included multiple, effective herbicide groups and create a long-term, resilient weed management plan. A survey conducted shortly after the meeting revealed that farmers and crop advisors acquired a better understanding of herbicide groups and designing herbicide programs with multiple, effective sites-of-action, were interested in attending a future "Weeds Week" program, and would encourage others to attend as well. Iowa State University plans to continue using this pilot effort and develop additional Weeds Week curricula to meet this growing need for our clients.

WINTER ANNUAL WEED RESPONSE TO NITROGEN SOURCES AND APPLICATION TIMINGS PRIOR TO A BURNDOWN CORN HERBICIDE. Kelly A. Nelson*; University of Missouri, Novelty, MO (171)

Winter annual weeds are common in no-till corn production systems. Autumn and early preplant N applications, sources, and placement may affect winter annual weed growth. Field research evaluated the effect of nitrogen sources applied in the autumn and early preplant for no-till corn on total winter annual weed growth (2006-2010), and evaluated strip-till and broadcast no-till N applied in the autumn and early preplant on henbit (*Lamium amplexicaule* L.) growth (2008-2010) prior to a burndown herbicide application. Total winter annual weed biomass was greater as a result of an autumn or early preplant N application of certain N sources for no-till corn which was due to the placement, availability of N, and/or injury caused by the N source. Total winter annual weed density was affected by N source with anhydrous ammonia having the lowest average weed density (95 weeds m^{-2}), but results were inconsistent over the years evaluated. Winter annual weed biomass was lowest (43 g m^{-2}) when 32% urea ammonium nitrate was applied in autumn, and was similar to anhydrous ammonia applied in autumn or early preplant and the non-treated control. Henbit biomass was 28% greater when N was applied in the autumn compared to an early preplant application timing. Nitrogen placement along with associated tillage with strip-till placement was important in reducing henbit biomass. Nitrogen source selection, application timing, and placement affected the impact of N on winter annual weed growth and should be taken into consideration when recommending a burndown herbicide application timing.

IMPROVING CANOPY PENETRATION IN CEREALS AND CANOLA: WHAT HAVE WE LEARNED THROUGH OUR INTENSIVE 2-YEAR STUDIES IN AUSTRALIA? J Connor Ferguson*[1], Chris C. O'Donnell[1], John H. Moore[2], Bhagirath S. Chauhan[3], Steve W. Adkins[4], Greg R. Kruger[5], Rodolfo G. Chechetto[6], Andrew J. Hewitt[7]; [1]University of Queensland, Gatton, Australia, [2]Department of Agriculture and Food Western Australia, Albany, Australia, [3]Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Toowoomba, Australia, [4]The University of Queensland, Gatton, Australia, [5]University of Nebraska-Lincoln, North Platte, NE, [6]The University of Queensland, São Paulo State University - FCA, Gatton, Australia, [7]The University of Queensland, University of Nebraska-Lincoln, Gatton, Australia (172)

Consistent spray coverage that is evenly distributed throughout the canopy is necessary to control pest populations that can negatively affect yield. As applicators are switching to Coarser spray quality nozzles to reduce risk and liability of pesticide spray drift, concerns about efficacy loss are growing. Previous research has indicated that small droplets are the most effective at penetrating through crop canopies, but newer nozzle technologies have improved the effectiveness of larger droplet or Coarser sprays. Two studies in Australia over two years have been conducted to assess the canopy penetration of nozzles that produce Coarse, Very-Coarse and Extremely-Coarse spray qualities compared to nozzles that produce Fine and Medium spray qualities. The canola study used water sensitive papers at four heights (10, 30, 50, 100 cm) in a canola crop to quantify the coverage and droplet number densities (droplets cm^{-2}) across two application volume rates: 50 and 100 L ha^{-1}. Results from the canola study showed reduced coverage at lower depths with the Coarse nozzles, but Results showed that droplet number densities were inversely related to the droplet size produced by the nozzles, yet coverage was increased more by application volume rate than droplet size. Results from the canola study observed no reduction in pest numbers with a Coarse spray compared to a Fine spray, even with differences in canopy penetration results. The other study used Kromekote® collectors positioned in four configurations in an oat (*Avena sativa* L.) var. 'Yarran' (AusWest Seeds, Forbes, NSW, Australia) crop. The study in oats compared nine different nozzles that produce five different spray qualities at three application carrier volume rates: 50, 75 and 100 L ha^{-1}. The results from this study observed that spray quality was less of a factor influencing coverage, where some coarser sprays deposited better than finer sprays. Thus, both spray drift reduction and improved canopy penetration can be achieved with proper nozzle selection and operation parameters for the control of agronomic pests. Results from both studies are helping to select better technologies and application parameters to improve the ability of sprays to move through dense canopies and reduce pest populations.

EFFICACY OF FOMESAFEN +/- DICAMBA APPLIED WITH LOW-DRIFT NOZZLES IN SIMULATED COMMERCIAL APPLICATIONS. Dain E. Bruns*, R. Joseph Wuerffel, Thomas H. Beckett, Donald J. Porter; Syngenta Crop Protection, Greensboro, NC (173)

Forthcoming transgenic soybeans resistant to synthetic auxin herbicides will require the use of low-drift nozzles that deliver very coarse to ultra-coarse droplets. It is well documented that efficacy of systemic herbicides applied with low-drift nozzles is generally adequate. Less clear is the effect of low-drift nozzles on the efficacy of herbicides with contact activity, applied alone or in a systemic tank-mixture partner. In particular, data is lacking for these applications made via commercial or simulated-commercial application equipment. Flexstar® is a herbicide containing the active ingredient fomesafen that provides contact activity for control of broadleaf weed species. Field trials were conducted to compare the efficacy of Flexstar +/- dicamba (a synthetic auxin herbicide) applied using several nozzle types that delivered medium, very coarse, or ultra-coarse droplets. Applications were made using commercial or simulated-commercial application equipment. Results indicated that Flexstar in combination with dicamba provided excellent broadleaf weed control, regardless of the nozzle type utilized for application. Flexstar applied alone was most efficacious when applied through nozzles delivering medium droplets.

RELATIVE VOLATILITY OF 2,4-D FORMULATIONS UNDER FIELD CONDITIONS. Ethan T. Parker*, Thomas C. Mueller; University of Tennessee, Knoxville, TN (174)

As herbicide resistance continues to be at the forefront of herbicide research, old herbicide technologies are seeing a resurgence in use. New 2,4-D formulations are being developed in an effort to reduce off-target movement via volatilization. Studies were performed to develop a method to quantify volatility of 2,4-D low-volatile ester and 2,4-D amine salt formulations for future comparison with new 2,4-D formulations. No-till soybean plots measuring 15 by 15 m at V3-V5 stage were treated with either Weedar 64® (2,4-D amine) or 2,4-D ester formulations at 1120 g ae ha^{-1}. Plots were sprayed in early morning with no wind. Approximately 15 min after application, high volume (283 L m^{-1}) air samplers were placed into each plot, and one in a non-treated plot at least 300 m from those receiving treatment. Each sampler was equipped with both polyurethane foam (PUF) collectors and filter paper to recover any volatile material. PUFs and filters were changed at 6, 12, 24, and 36 hrs after treatment (HAT). Each sample was placed in bags within coolers and transported immediately to a freezer until extraction. Assay was done using chemical extraction followed by liquid chromatography mass spectroscopy. The study was conducted twice, with two samplers collecting each respective 2,4-D formulation. Environmental conditions, especially temperature, affected the results observed. Recovery of volatile 2,4-D for formulations was highest during the 6-12 hr interval, followed by the 24-36 hr interval, which were both during the warmest parts of the day. Considering the relative volatility of ester to amine amounts in the published literature, the recovery of 2,4-D ester was much lower than expected. When the control samples from the spray mixtures were analyzed, it was determined that the the 2,4-D ester was not at full strength and was only ~11% acid equivalent of the original formulation. Overall, the methods utilized for the detection of volatility of 2,4-D formulations are adequate and will be used in future research.

PERFORMANCE OF CERTAIN HERBICIDES AS INFLUENCED BY NOVEL ADJUVANT SYSTEMS. Ryan J. Edwards*[1], Greg K. Dahl[2]; [1]WinField Solutions, River Falls, WI, [2]WinField Solutions, River falls, WI (175)

The performance of certain herbicides is increased with the use of oil type adjuvants. However, oil adjuvants are not recommended for use with glyphosate. Methylated Seed Oil-High Surfactant Oil Concentrates (MSO-HSOC) are a newer generation of oil based adjuvants. MSO-HSOC (e.g. Destiny HC and Superb HC) are based on 25-50% w/w surfactant with a minimum of 50% w/w oil. MSO-HSOC have shown excellent compatibility with glyphosate while providing equivalent performance as other oils. A new MSO-HSOC (AG14039) provides optimal weed efficacy similar to other HSOC adjuvants and added drift control. Field trials were conducted across the U.S. on multiple crop types and weeds to determine the effect of AG14039 on the performance of fomesafen, saflufenacil, clethodim, quinclorac + imazethapyr, topramazone and glyphosate. In all trials, AG14039 provided similar weed efficacy as compared to similar MSO-HSOC for velvetleaf, common lambsquarter, pigweeds, volunteer corn and other weeds.

ENHANCING OIL-BASED ADJUVANT ACTIVITY. Patrick M. McMullan*[1], Keith Rowley[2], Nongnuch Sutivisedsak[2]; [1]United Suppliers, Inc., Ames, IA, [2]Ag Precision Formulators, Middleton, WI (176)

Minimizing off-target drift should be the target of every spray application. However, if we utilize coarser nozzles to reduce the drift risk, there is the potential for reduced herbicide efficacy. Previous research has demonstrated that herbicide efficacy can be reduced when sprayed through coarser (drift reducing nozzles) compared to less coarser nozzles. The reduction in efficacy may be partly explained by lower spray retention when using coarser nozzles due to the larger spray droplets produced. Oil based adjuvants, such as high surfactant crop oil concentrates and high surfactant methylated seed oils, are often applied with postemergence herbicides. By definition, a high surfactant oil concentrate contains at least 50% oil and at least 25% emulsifier. This definition allows for the inclusion of additional material in the high surfactant formulation while meeting the definition of the adjuvant. A research project was initiated to determine if additional materials can be formulated into a high surfactant oil concentrate and improve spray retention and subsequently herbicide efficacy. A series of high surfactant oil concentrates were formulated to determine if spray retention and herbicide efficacy can be increased when these types of adjuvants are included in the spray mixture. Spray droplet spectrum/characteristics, spray retention, and herbicide efficacy were all evaluated with the experimental formulations compared to conventional formulations and results will be discussed.

SPECIES RESPONSE TO DEW, HERBICIDES AND ADJUVANTS. Donald Penner*, Jan Michael; Michigan State University, East Lansing, MI (177)

It is often desirable to apply postemergence herbicides early in the morning when the wind velocity may be at its lowest to minimize drift. However, dew may be present on the leaves and the applicator may be ambivalent on whether or not to spray until this dew dries. The objective of this research was to determine what effect dew has on glyphosate activity applied with various adjuvants on three weed species, velvetleaf, common lambsquarters, and giant foxtail. The effect of dew on glyphosate activity, if any, was an occasional increase in glyphosate activity with heavy dew. This was most often observed with giant foxtail.

A COMPARISON OF TANK CLEANING CHEMICALS TO REMOVE DICAMBA RESIDUES FROM SPRAY EQUIPMENT. Thomas C. Mueller*[1], Frank Sexton[2]; [1]University of Tennessee, Knoxville, TN, [2]Exacto, Inc, Sharon, WI (178)

With greater complexity of herbicide use patterns, tank contamination will be a growing challenge to pesticide users. The specific goal of this project is to develop a quantifiable test system to discern differences in commercially available tank cleaners to remove herbicide residues from tank parts, hoses etc. A search of the refereed literature found no citations on this topic. An overview of the method consists of applying a known amount of herbicide to simulated tank parts, allowing that material to dry, removing them with various treatments, and quantifying the difference using chemical assay. For this study we looked at dicamba at 1120 g ae + glyphosate at 840 g ae in the spray mixture of 94 L $^{ha-1}$. The proposed method is flexible in that any pesticide mixture could be potentially examined. The tank parts were placed into a fume hood operating at normal capacity, and 1.0 mL of the spray solution was added in 16 to 24 drops to the top of each tank part. These were then allowed to dry for approximately 24 hours at room temperature. Foundational to the success of the method is loading each test unit with the same amount of spray mixture. Primary studies showed this was possible using lab pipetting equipment with a mean a +1 or -1%. Another key step learned from previous research was that the mechanical agitation of the treated tank parts was critical, in that how long you shook the treatment was very impactful on the outcome. For this reason an additional step was added to the method from previous versions; that of a preliminary step to determine the interval for tank cleaning exposure. Operational details of the method will be discussed in the presentation. Treatments had detectable dicamba concentrations using a liquid chromatograph with a diode array detector. There were statistically different pHs and recoveries from the various tank cleaners. The results of the study showed that the method can be sensitive to the operator, so care must be taken to standardize procedures. The total recovery of the dicamba was nearly 100%, indicating that none was volatilizing while drying in the hood. There were minimum chromatography issues in the analysis even though there was a wide range of pH and surfactant loads, although we did dilute the raw extracts into methanol for analysis. The method described uses minimum solvent and no special equipment was required. The test system proposed can determine the most effective treatments to remove pesticide residues, and is flexible to examine different matrices.

HERBICIDE PROGRAMS FOR KOCHIA CONTROL IN DICAMBA-TOLERANT SOYBEANS. Jeffrey T. Krumm*[1], David H. Johnson[2], Keith D. Johnson[3], Bruce V. Steward[4], Robert N. Rupp[5]; [1]DuPont Crop Protection, Hastings, NE, [2]DuPont Crop Protection, Johnston, IA, [3]DuPont Crop Protection, Grand Forks, ND, [4]DuPont Crop Protection, Overland Park, KS, [5]DuPont Crop Protection, Edmond, OK (179)

No abstract submitted

HERBICIDE PROGRAMS FOR MARESTAIL CONTROL IN DICAMBA-TOLERANT SOYBEANS. Jessica R. Bugg*[1], Jeffrey T. Krumm[2], Keith A. Diedrick[3], Kelly A. Backscheider[4], Kevin L. Hahn[5], David H. Johnson[6]; [1]DuPont Crop Protection, Marysville, OH, [2]DuPont Crop Protection, Hastings, NE, [3]DuPont Crop Protection, Madison, WI, [4]DuPont Crop Protection, Shelbyville, IN, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Johnston, IA (180)

No abstract submitted

ENGENIA HERBICIDE: OPTIMIZING PERFORMANCE AND PRODUCT STEWARDSHIP IN DICAMBA TOLERANT CROPS. John Frihauf*[1], Chad Brommer[2], Joseph Zawierucha[2], Steven Bowe[3]; [1]BASF, Lincoln, NE, [2]BASF, Research Triangle Park, NC, [3]BASF, RTP, NC (181)

New weed control options are needed to manage herbicide-resistant weeds that are limiting control tactics and in some areas cropping options. Dicamba-tolerant (DT) soybeans 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, DT soybeans will allow for application of dicamba as a preplant burndown without a planting interval and postemergence over the top of the crop. Engenia™ herbicide will be an advanced formulation (EPA approval pending) based on the BAPMA (N, N-Bis-aminopropyl) methylamine) form of dicamba, with registration expected in 2016. Stewardship of Engenia herbicide will be a two pronged approach focused on weed management and maximizing on-target application. Effective control and management of resistant weeds with Engenia herbicide will utilize Engenia herbicide as a complimentary tool in a grower's weed control program where it should be integrated into a comprehensive strategy that includes cultural, mechanical, and chemical control. A robust herbicide program uses sequential and/or tank-mixtures of herbicides that have multiple effective sites-o- action on target weed species. Likewise, Engenia herbicide will complement current programs by adding an additional effective site-of-action for broadleaf weed control in soybean. BASF field trials in DT soybeans have demonstrated that postemergence use of dicamba with glyphosate and other effective herbicides following a preemergence or preplant residual herbicide program often provides the most consistent and effective control. On-target application is influenced by many parameters related to equipment setup and environmental conditions. Proper nozzle selection can dramatically reduce the potential for spray drift and maximize on-target deposition. BASF research shows that nozzles that produce extremely to ultra-coarse spray droplets can reduce drift potential. Proper nozzle selection (extremely to ultra-coarse droplet) coupled with appropriate boom height (≤24"), application volume (94 l $^{ha-1}$ minimum), travel speed (≤24 km^{h-1}), and awareness of proximity to sensitive crops. The combination of Engenia herbicide and dicamba tolerant crops is expected to provide growers with an effective system to help control increasingly difficult and herbicide-resistant broadleaf weeds.

MULTI-CROP BIOASSAY OF SIMULATED DICAMBA RESIDUE IN SOIL. Theresa A. Reinhardt*, Rich Zollinger; North Dakota State University, Fargo, ND (182)

Dicamba (3,6-dichloro-2-methoxybenzoic acid) is a common growth regulator herbicide used to control broadleaf weeds. The introduction of dicamba-resistant soybean (*Glycine max L.*) and the subsequent anticipated increase in dicamba use rates creates an elevated risk to susceptible crops in adjacent fields or in rotational crops. Producers grow a variety of crops that are susceptible to this chemical so adequate precautions should be taken. This study addresses potential of soil residual dicamba to cause injury to four susceptible, high value crops: dry bean (*Phaseolus vulgaris L.*), soybean, sugar beet (*Beta vulgaris L.*), and sunflower (*Helianthus annuus L.*). Experiments were conducted near Erie and Hillsboro, North Dakota. Rates of dicamba from 0 -184 g ha^{-1} were applied to bare ground in mid-May to simulate dicamba residues remaining from the previous year. Each crop was planted into the treated area. The effect of dicamba on the growth and development of the crops was measured in three ways. Stand counts were taken at emergence and before harvest. Visible injury was recorded as a percentage (100% = total death) at 7, 14, 21, and 24 d after emergence. Seed and beet weights were taken at harvest. Using this information, growers can adjust management strategies and practices to accommodate the potential increased use of dicamba in fields.

INTERACTION BETWEEN XTENDIMAX™ AND GROUP 1 HERBICIDES FOR VOLUNTEER CORN CONTROL IN SOYBEAN. Matthew G. Underwood*[1], Peter Sikkema[1], David C. Hooker[2], Darren E. Robinson[1], Joseph P. Vink[3]; [1]University of Guelph, Ridgetown, ON, [2]University of Guelph\, Ridgetown, ON, [3]Monsanto Canada, Winnepeg, MB (183)

Weed control is an ongoing challenge for farmers. Since the introduction of glyphosate-resistant crops in 1996, several weeds have evolved resistance to glyphosate, the most used herbicide worldwide, further increasing the difficulty of achieving acceptable weed control. A transgenic soybean cultivar has been developed with resistance to both glyphosate and dicamba (RR Xtend Soybean). Applying glyphosate plus dicamba reduces soybean yield losses caused by glyphosate-resistant weeds. However, there is a risk of herbicide antagonism reducing control of monocot weeds when Group 1 herbicides are co-applied with dicamba. Six field experiments were conducted over two years at three sites in south-western Ontario to determine the effect of tank-mixtures of dicamba with Group 1 herbicides for controlling volunteer corn. Two rates of dicamba (300 and 600 g $^{ha-1}$), using the Xtendimax^{TM} herbicide formulation, were co-applied with quizalofop-p-ethyl (24, 30, and 36 g $^{ha-1}$) and clethodim (30, 37.5, or 45 g $^{ha-1}$), when volunteer corn reached the V4 growth stage. Weed control and crop yield were evaluated. Reduced volunteer corn control and yield were greatest in tank-mixtures containing the high rate of dicamba and low rate of the Group 1 herbicide. The high rate of dicamba and low rate of quizalofop-p-ethyl resulted in yield losses above 1.25 Mg $^{ha-1}$. The addition of dicamba to quizalofop-p-ethyl resulted in greater antagonism than when co-applied with clethodim. This research indicates that farmers wishing to control volunteer corn and glyphosate-resistant weeds, may need to increase their Group 1 herbicide rate or apply the two herbicides sequentially.

EFFICACY OF SEQUENTIAL HERBICIDE PROGRAMS CONTAINING FOMESAFEN AND SEEDLING SHOOT INHIBITORS IN SOYBEANS. Timothy L. Trower*[1], Brett Miller[2], Donald J. Porter[3], Thomas H. Beckett[3]; [1]Syngenta, Baraboo, WI, [2]Syngenta, Minnetonka, MN, [3]Syngenta, Greensboro, NC (184)

Planned preemergence followed by postemergence sequential weed control programs in soybeans offer many weed control advantages over postemergence only programs. The opportunity to use multiple effective modes-of-action in a sequential program can improve the weed control spectrum and is an important component of herbicide resistance management. These sequence programs can also improve soybean yields and economic return. Field trials were conducted to evaluate the broad-spectrum, season-long weed control of *s*-metolachlor + metribuzin or *s*-metolachlor + sulfentrazone followed by a sequential postemergence application of fomesafen or fomesafen + *s*-metolachlor. Results show that these planned sequential programs with overlapping residual herbicides will control many difficult weeds, including glyphosate-resistant broadleaf weeds in soybeans.

REFRESHING RESIDUALS: VALUE OF METRIBUZIN + FLUMIOXAZIN FOR WEED CONTROL IN SOYBEANS. Dawn Refsell*[1], Lowell D. Sandell[2], Eric J. Ott[3], Trevor M. Dale[4], Ron Estes[5], John A. Pawlak[6]; [1]Valent USA Corporation, Lathrop, MO, [2]Valent USA Corporation, Lincoln, NE, [3]Valent USA Corporation, Greenfield, IN, [4]Valent USA Corporation, Minneapolis, MN, [5]Valent USA Corporation, Champaign, IL, [6]Valent USA Corporation, Lansing, MI (185)

Weed resistance management strategies focus primarily on multiple effective modes-of-action. Flumioxazin is formulated and sold as a single active, thus allowing tank-mixtures with other desired active ingredients to occur. Metribuzin has been proven to provide burndown activity of winter annuals in addition to having activity on kochia and amaranth species. Trials were conducted over five years and multiple locations to determine the addition of metribuzin to flumioxazin alone and flumioxazin + pyroxasulfone as it pertains to crop safety, efficacy, and resistance management though increasing modes-of-action. The three-way mixture of flumioxazin + pyroxasulfone + metribuzin resulted in increased efficacy for Palmer amaranth, common ragweed, barnyardgrass, and giant foxtail over competitive standards and flumioxazin alone. Flumioxazin + metribuzin also improved control for morningglory and lambsquarters over flumioxazin alone. Crop response was evident in some trials 14 DAT; however, by evaluation 28 DAT it was no longer significant.

WARRANT ULTRA: A NEW RESIDUAL AND POSTEMERGENCE HERBICIDE OPTION IN SOYBEAN. Justin Pollard*[1], John Willis[2], Ryan Rapp[3]; [1]Monsanto, Lathrop, MO, [2]Monsanto, Creve Coeur, MO, [3]Monsanto, Mitchell, SD (186)

A diversified weed management program is an essential component of modern crop production systems to manage herbicide-resistant weeds and protect crop yield. Several tactics exist to control herbicide-resistant weeds including the use of multiple sites-of-action herbicide pre-mixtures. Warrant® Ultra Herbicide is a new herbicide pre-mixture developed by Monsanto for use in soybean. Warrant® Ultra Herbicide is a capsule suspension formulation of microencapsulated acetochlor and fomesafen (WSSA Groups 15 and 14, respectively) that provides residual control of broadleaf weeds and annual grasses as well as activity on emerged broadleaf weeds. Field trials were conducted in 2014 and 2015 to evaluate Warrant® Ultra Herbicide for residual and postemergence weed control as well as crop safety compared to commercial standards. Our results show that Warrant® Ultra Herbicide applied alone and in a systems approach with other herbicides in Genuity® Roundup® Ready 2 Yield® soybeans can control many tough to control weeds in soybean while providing improved crop safety.

NEW ZERO-DAY PLANT-BACK OPTIONS FOR DUPONT™ BASIS® BLEND AND LEADOFF® HERBICIDES IN BOLT™ TECHNOLOGY SOYBEAN . Paul Marquardt*[1], Kevin L. Hahn[2], Michael D. Meyer[3], Larry H. Hageman[4], Kelly A. Backscheider[5], Keith A. Diedrick[6], Keith D. Johnson[7], Scott E. Swanson[8], Jeffrey T. Krumm[9], Richard M. Edmund[10], David H. Johnson[3]; [1]DuPont Crop Protection, Des Moines, IA, [2]DuPont Crop Protection, Bloomington, IL, [3]DuPont Crop Protection, Johnston, IA, [4]DuPont Crop Protection, ROCHELLE, IL, [5]DuPont Crop Protection, Shelbyville, IN, [6]DuPont Crop Protection, Madison, WI, [7]DuPont Crop Protection, Grand Forks, ND, [8]DuPont Crop Protection, Rochelle, IL, [9]DuPont Crop Protection, Hastings, NE, [10]DuPont Crop Protection, Little Rock, AR (187)

No abstract submitted

UTILITY OF ARYLEX™ ACTIVE HERBICIDE FOR PRE-PLANT BURNDOWN APPLICATIONS. Jeff M. Ellis*[1], Chris Voglewede[2], Joe Armstrong[3], Leah Granke[4], Laura A. Campbell[5], Kristin Rosenbaum[6], Mark A. Peterson[7], David Simpson[2]; [1]Dow AgroSciences, Sterlington, LA, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Davenport, IA, [4]Dow AgroSciences, Columbus, OH, [5]Dow AgroSciences, Carbonale, IL, [6]Dow AgroSciences, Crete, NE, [7]Dow AgroSciences, West Lafayette, IN (188)

Arylex™ (halauxifen-methyl), a new active ingredient from Dow AgroSciences, is a novel synthetic auxin (WSSA group 4) herbicide from the new "arylpicolinate" chemical class. It is being developed for the U.S. pre-plant burndown market segment for control of horsweed *Conyza canadensis(L.) Cronq* and other problematic broadleaf weeds. The first U.S. burndown product will be an SC formulation, with a use rate of 1.0 fl oz product/acre [Arylex (halauxifen-methyl 5.0 g ae/ha)] and will be labeled for use prior to soybean and corn planting. Initial labeling will allow application up to 14 d prior to planting of soybean and corn. Field research was conducted from 2013 to 2015 at 15 locations across the U.S. to determine the efficacy of Arylex applied in the spring to horseweed, including glyphosate-resistant biotypes, and other common weeds prior to planting soybean and corn. Arylex was compared to competitive standards when applied with glyphosaste and in tank-mixtures with glyphosate + 2,4-D LVE herbicide. Arylex applied at 5.0 g ae/ha + glyphosate at 1120 g ae/ha demonstrated similar to or better control of marestail when compared to Liberty (glufosinate) at 542 g ae/ha, Clarity (dicamba) at 280 g ae/ha + glyphosate 1120 g ae/ha, and Sharpen (saflufenacil) at 37.5 g ai/ha + glyphosate at 1120 g ae/ha. Crop injury was evaluated in efficacy trials as well as dedicated weed-free crop tolerance trials. Results indicated that soybean and corn can be planted 14 d after application of Arylex without injury. Arylex will provide growers with an alternative mode-of-action for many difficult to control pre-plant burndown broadleaf weeds such as horseweed and henbit *Lamium amplexicaule L*.

INTRODUCING BOLT™ TECHNOLOGY: A NEW HERBICIDE SYSTEM FOR CLEANER FIELDS AND GREATER MANAGEMENT FLEXIBILITY IN SOYBEANS. David Johnson*[1], Helen A. Flanigan[2], Jeff Carpenter[1], Steven Strachan[3], Steven Mitchell[4], Andre Trepanier[4], Mark Vogt[4], Scott Sebastian[4]; [1]DuPont Crop Protection, Johnston, IA, [2]DuPont, Greenwood, IN, [3]DuPont Crop Protection, Newark, DE, [4]DuPont Pioneer, Johnston, IA (189)

EXAMINING THE TOLERANCE MECHANISM OF GRASS TO ISOXABEN. Chad Brabham*, Seth Debolt; University of Kentucky, Lexington, KY (190)

Grasses are tolerant to a subclass of cellulose biosynthesis-inhibitors that include the turf herbicide isoxaben (Gallery). In this research, we examined the potential target and non-target resistant mechanisms of the model C_3 grass species *Brachypodium distachyon* to isoxaben. Brachypodium did not sufficiently metabolize ^{14}C-Isoxaben to explain tolerance. Point mutations that confer resistance to isoxaben in *Arabidopsis* have been mapped to cellulose synthase proteins (CESA) 3 and 6, however these mutations were not found in Brachypodium *CESA3* and *6* orthologs. We also complemented *Arabidopsis cesA3* and *cesA6* mutants with Brachypodium CESAs to determine if any unknown amino acid changes could confer resistance. Additionally, we tested if unique grass cell wall components, specifically mixed linkage glucans, could provide increased isoxaben tolerance in gain of function transgenic Arabidopsis plants. Results will be presented and further put into context as to provide an explanation into isoxaben tolerance in grass.

GENOMIC AND MOLECULAR FINDINGS IN KOCHIA (KOCHIA SCOPARIA). Philip Westra*[1], Todd Gaines[2]; [1]Colorado State University, Ft. Collins, CO, [2]Colorado State University, Fort Collins, CO (191)

Modern weed control based largely on herbicides has increasingly run head on into difficult and significant issues of herbicide resistant weeds which compromise the utility of some of the best products in the marketplace. Weed biology focused on a variety of weed issues including, resistance, dormancy, competitive ability, traits that ensure weed success, etc., sits at the crossroads of many lines of research including agronomy, chemistry, biochemistry, ecology, and more recently molecular biology, in part due to the evolution of herbicide resistance. Molecular biology itself is being revolutionized by next-generation and third generation sequencing techniques, allowing us to quickly generate nucleotide databases. To better integrate weed biology in future agriculture challenges, genetic tools including the transcriptomes and the genomes of model weedy organisms need to be developed and made available to the research community not only to improve weed control, but also to mine weeds for desirable traits that could enhance crop productivity. Current "model" plant species do not have the same traits or complexity as many weedy species making them less effective models. Our research team has begun the ambitious effort of

sequencing the genome of *Kochia scoparia*, an important weed in the western USA that has evolved multiple herbicide resistance mechanisms. *K. scoparia* is a member of the family Chenopodiaceae, a sister taxon to Amaranthaceae family. *K. scoparia's* relatedness to many other important weedy species (including *Amaranthus* spp.) as well as important crop species (sugar beet and spinach, both in Chenopodiaceae) makes it a good candidate for developing molecular biology research tools. The large, complex, and malleable genome of *K. scoparia* makes sequencing and genome assembly an interesting challenge. It appears that the large genome (haploid size of 1.0-1.3 Gb) is due to a recent polyploidy event in the Chenopodiaceae lineage, resulting in large highly repetitive regions that are difficult to resolve without more advanced approaches to sequencing. We have utilized both Illumina and PacBio sequencing technologies to conduct a hybrid-platform draft assembly of the *K. scoparia* genome. Our initial findings demonstrate the challenges in assembling complex weedy species genome and potential for using cutting-edge molecular tools to improve our understanding of weed biology and weedy traits.

TARGET AND NON-TARGET SITE MULTIPLE HERBICIDE RESISTANCE IN PALMER AMARANTH (*AMARANTHUS PALMERI*) FROM KANSAS. Vijay K. Varanasi*[1], Sridevi Betha[1], Curtis R. Thompson[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State, Manhattan, KS (192)

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is an aggressive, summer annual broadleaf weed that infests several cropping systems throughout the U.S. Availability of extensive genetic variability coupled with intense selection pressure resulted in evolution of resistance to herbicides with different modes-of-action (MOA) in Palmer amaranth. In this study, a Palmer amaranth population from Hutchinson, KS, was screened for resistance to PSII-, ALS-, and EPSPS-inhibitors, and their mechanism-of-resistance was investigated. Seedlings were treated separately with 1x dose of atrazine at 2240 g ai/ha, chlorsulfuron at 18 g ai/ha, or glyphosate at 840 g ae/ha. Plants that survived herbicide treatments were sequenced for *psbA*, *ALS*, and *EPSPS* genes, the target sites of atrazine, chlorsulfuron, and glyphosate, respectively. Quantitative PCR was performed to determine the *EPSPS* gene copy number. The clones of atrazine-resistant plants, produced by nodal cuttings were treated separately with chlorsulfuron to evaluate the evolution of multiple herbicide resistance (MHR) in a single individual. Sixty-percent of plants survived 1x dose of atrazine with no known *psbA* gene mutation, indicating a non-target site based mechanism-of-resistance. Twenty-four percent of plants survived 1x dose of chlorsulfuron with a Pro_{197} to Ser, Thr, Ala, or Asn substitution, suggesting that point mutations within the gene encoding for ALS are responsible for resistance to this herbicide in this population. About 33% of the plants survived 1x dose of glyphosate with no known mutations in the *EPSPS* gene. Quantitative PCR results revealed *EPSPS* gene amplification (50-140 copies) as the mechanism-of-resistance to glyphosate. Therefore, Palmer amaranth population from this location, exhibiting target as well as non-target site resistance mechanisms to three herbicide MOA, is a challenge for reaping sustained crop production benefits.

DISTRIBUTION OF *EPSPS* COPIES IN METAPHASE CHROMOSOMES OF GLYPHOSATE-RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*). Mithila Jugulam*, Dal-Hoe Koo, Karthik Putta, Dallas E. Peterson, Bernd Friebe, Bikram S. Gill; Kansas State University, Manhattan, KS (193)

Amplification of 5-enolpyruvylshikimate-3-phosphate synthase (*EPSPS*) gene (> 100 copies) has been confirmed in several glyphosate-resistant (GR) Palmer amaranth populations across the U.S. Furthermore, previous studies reported distribution of amplified *EPSPS* copies throughout the genome of Palmer amaranth, possibly via transposable elements. In this study, we determined the copy number and configuration of *EPSPS* copies on prophase and metaphase chromosomes of glyphosate-susceptible (GS) and GR Palmer amaranth populations from KS. Genomic DNA was extracted from young leaves (~50 mg fresh wt) of several plants from these populations. Using SYBR green-based quantitative real-time PCR (qRT PCR) assay, the *EPSPS* copy number was measured by $\Delta\Delta$Ct method with β-tubulin gene as an endogenous control. Fluorescent in situ hybridization (FISH) was used to determine the chromosomal location and distribution of *EPSPS* copies. The analyses of qRT PCR showed differences in the *EPSPS* gene copy number among the samples; the GS plants had 1 copy, whereas, the GR population possessed ~12 up to > 100 *EPSPS* copies. FISH analysis performed on prophase and metaphase chromosomes of GS, GR with ~12 or 20 (low) and ~70 to 90 (high) *EPSPS* copies exhibited differences in distribution of amplified copies. A faint hybridization site was displayed in GS plants, whereas, a brighter hybridization signal on one pair of homologous chromosomes likely near the centromeric region was found in GR Palmer amaranth with low (12 or 20) *EPSPS* copies. However, GR plants with high (~70 or 90) *EPSPS* copies showed brighter hybridization signal on all the chromosomes throughout the genome. These results suggest that alterations in the *EPSPS* gene copy number in somatic cells of GR Palmer amaranth initially may occur via unequal recombination (plants with low *EPSPS* copies) and subsequently, possibly via transposon mediated amplification (plants with high *EPSPS* copies).

HERBICIDE-RESISTANCE GENES DO NOT ALWAYS SHOW INDEPENDENT ASSORTMENT. Patrick Tranel*[1], Chenxi Wu[2], Ahmed Sadeque[1]; [1]University of Illinois, Urbana, IL, [2]University of Illinois at Champaign-Urbana, Urbana, IL (194)

A weed with multiple herbicide resistance has two or more genes that confer the resistances. In general, there is a high probability that these genes will be at different locations in the genome and, therefore, will follow Mendel's law of independent assortment. Anecdotal observations of waterhemp populations with target-site resistances to ALS and PPO inhibitors suggested the ALS and PPO genes were not following independent assortment. Research therefore was conducted to investigate possible linkage of these two genes. Plants with resistance to both ALS and PPO inhibitors were crossed with herbicide-sensitive plants, and resultant F_1 plants were backcrossed to sensitive plants. Inheritance of ALS and PPO resistance alleles was analyzed in three backcross populations using both whole-plant resistance phenotyping and molecular markers. The ALS and PPO resistance traits co-segregated in 90 to 95% of the progeny in all three backcross populations. The recently published genome of grain amaranth allowed us to investigate physical linkage of the ALS and PPO genes in this closely related species. As expected based on our observations of genetic linkage, the two genes were found to be assembled within a single contig, and they were only 182 kb apart. Documentation of linkage between the ALS and PPO genes in *Amaranthus* spp. is a reminder that multiple resistance genes cannot be assumed to independently assort. Linkage of resistance genes could influence their evolution in populations and could also confound genetic-based approaches to identify genes responsible for specific herbicide-resistance traits.

METHIOZOLIN, IT MAY NOT WORK HOW YOU THINK. Chad Brabham*, Jarrad W. Gollihue, Seth Debolt, Michael Barrett; University of Kentucky, Lexington, KY (195)

PoaCure is a new herbicide for selective control of *Poa annua* in golf greens. The active ingredient in PoaCure is methiozolin. Its mode-of-action is currently unknown but two mechanisms have been purposed. The first mechanism is inhibition of cellulose biosynthesis and the second mechanism is inhibition of carotenoid synthesis by inhibiting the conversion of tyrosine into 4-hydroxylphenylpyruvate (4 HPP). In this study we use confocal microscopy, tyrosine aminotransferase mutants (*tats*), and feeder assays to test these two hypotheses.

MANAGING CO-INVADED FOREST ECOSYSTEMS: LESSONS FROM RESEARCH ON CO-OCCURRING INVASIVE PLANTS. Sara Kuebbing*; Yale University, New Haven, CT (197)

No abstract submitted

PATTERNS AND DRIVERS OF FOREST PLANT INVASIONS REVEALED FROM FIA DATA. Basil Iannone*; Purdue University, West Lafayette, IN (198)

No abstract submitted

DEVELOPING A SHORT AND LONG-TERM MANAGEMENT PLAN FOR BUSH HONEYSUCKLE MANAGEMENT. Steve Manning*; Invasive Plant Control Inc., nashville, TN (199)

No abstract submitted

BIOLOGY AND MANAGEMENT OF AMUR HONEYSUCKLE (LONICERA MAACKII). Reid J. Smeda*; University of Missouri, Columbia, MO (200)

Amur honeysuckle is a widespread, invasive shrub across the central and northeastern regions of the U.S. In the fall, attractive red berries are vectored by birds to virgin sites, contributing to the spread of infestations. Under natural conditions, little is known about the reproductive capacity of amur honeysuckle and timing of seed dissemination. To preclude additional infestations, herbicides were compared for effectiveness. From 2011 to 2012, field trials in central Missouri assessed mature shrubs for berry production (1-5 seeds per berry) and subsequently, bird predation. Seed production ranged from 2,840 to 7,160 seeds per shrub, with seeds first viable in September, reaching an optimum of 90% viability by mid-November. Birds predated an average of 250 honeysuckle berries per week, with 82% of predation occurring between October and the following January. Foliage of fall-mowed amur honeysuckle shrubs (one meter regrowth) was treated in late June to early July in 2010 and 2011 with industrial rates of herbicides from three different modes-of-action. Initial control (28 DAT) was >90% with aminocyclopyrachlor + metsulfuron + imazapyr, but varied from 16 to 87% for other treatments. By 120 DAT, aminocyclopyrachlor + metsulfuron and aminocyclopyrachlor + metsulfuron + imazapyr resulted in >90% control of shrubs at three of four site years. Glyphosate alone resulted in >90% control at two of four sites years. The following spring after application (270 DAT), only shrubs treated with aminocyclopyrachlor + metsulfuron + imazapyr or glyphosate alone did not require a sequential application to control regrowth. Preventing berry production is a critical step in slowing the spread of amur honeysuckle. Effective control of shrubs in infested areas likely requires herbicide applications.

AERIAL TREATMENT OF BUSH HONEYSUCKLE (*LONICERA MAACKII*) IN ILLINOIS. Andrew DiAllesandro*[1], Bob Caveny[2]; [1]U.S. Fish & Wildlife Service, Springfield, IL, [2]Illinois Department of Natural Resources, Springfield, IL (201)

Bush honeysuckle (*Lonicera maackii*) is a common invader of woodlands and forests in the Midwest that can have several negative impacts on the native plant community once established. Traditional management techniques used to treat bush honeysuckle can be both difficult and costly on large scale eradications and restorations. The Illinois Department of Natural Resources and the U.S. Fish and Wildlife Service, in conjunction with the Missouri Department of Conservation, have been investigating the use of aerial applications of herbicide to manage this troublesome species. Results from initial treatments, considerations for technique implementation, and possible future research will be discussed.

RATE LIMITATION AND EFFICACY TRIALS FOR LOW-VOLUME BASAL BARK TREATMENTS OF *CELASTRUS ORBICULATUS* AND *LONICERA MAACKII* WITH AMINOPYRALID AND TRICLOPYRâ€‹â€‹â€‹. Karla L. Gage*[1], Christopher W. Evans[2], Ernest S. Flynn[3], David J. Gibson[1]; [1]Southern Illinois University Carbondale, Carbondale, IL, [2]Illinois Department of Natural Resources, Benton, IL, [3]Dow AgroSciences, Lees Summit, MO (202)

Oriental bittersweet (*Celastrus orbiculatus;* CEOR) and Amur honeysuckle (*Lonicera maackii;* LOMA) are managed using low-volume basal bark herbicide applications; however, managers may risk exceeding labeled herbicide application rates in high stem densities. The addition of aminopyralid may enhance control efficacy while allowing a reduced rate of triclopyr in solution. The objectives of this study were: 1) to test rate limitation by establishing the relationship between stem density and volume of solution applied and 2) to test rate combinations of aminopyralid and triclopyr to determine control efficacy for CEOR and LOMA. To assess rate limitation, five m-diameter plots in separate stands of each species were established in varying stem densities. In each plot, stems were counted and measured. Replicate treatments were applied with water and converted to oil carrier with a conversion factor of 1.33. To determine control efficacy, five rate combinations (20% triclopyr; 15% triclopyr + 1% aminopyralid; 15% triclopyr + 2% aminopyralid; 10% triclopyr + 1% aminopyralid; 10% triclopyr + 2% aminopyralid) were applied to 105 individuals of each species. There was no treatment difference in mortality for CEOR after one year. For LOMA, the 15% triclopyr + 2% aminopyralid treatment was most effective. There was no risk of exceeding the labeled rate of triclopyr in the maximum estimated stem densities, with stems/acre of CEOR and LOMA estimated at 2,578 and 4,019, respectively. The risk of exceeding labeled rates for aminopyralid were estimated at 3,023 and 4,077 stems/acre, respectively, for a 1% (7 fl. oz/217 ml) rate and 5,869 and 8,232/acre for a 1% spot spray 0.5 acre (14 fl. oz/414 ml) rate; for a 2% rate, limits were 1,459 and 1,786 stems/acre (217 ml) and 2,886 and 3,862 stems/acre (414 ml) for CEOR and LOMA, respectively. Therefore, while the combination of aminopyralid and triclopyr can increase control efficacy for LOMA, managers may consider treating partial acreage in dense infestations to reduce risk of exceeding the labeled use rate.

THE JOY OF DOING IT THE HARD WAY: USING MANUAL METHODS TO CONTROL ASIAN BUSH HONEYSUCKLE. Jane Morse*; TREES Inc, Terre Haute, IN (203)

No abstract submitted

FUNCTIONAL GROUPS TO RESIST INVASION BY CANADA THISTLE (CIRSIUM ARVENSE) DURING PRAIRIE ESTABLISHMENT. Roger Becker*[1], Larry H. Hageman[2]; [1]Univ. of Minnesota, St. Paul, MN, [2]DuPont Crop Protection, ROCHELLE, IL (204)

Prairies are especially vulnerable to invasion by exotic plants during establishment. Poor or slow establishment of native grasses and forbs leave niches open to invasion, particularly by Canada thistle in Minnesota. Once established in these available niches, Canada thistle can quickly entrench competing with native forbs for establishment niches, ultimately diminishing forb cover and diversity. The objective of this study was to establish mesic tallgrass prairies with the potential to resist invasion by Canada thistle. This research was conducted at the University of Minnesota Southwest Research and Outreach Center at Lamberton, in southwest MN. At establishment, treatments consisted of planting season, seed mixes representing functional groups, and first season post-planting management practices. Planting seasons of early spring, summer and fall frost-seedings were repeated in time, with the first planting frost seeded in the fall of 2004. Seed mixes were warm season only or cool season only forbs and grasses, compared to a mixture of both warm and cool season native species. Post-planting management included doing nothing, clipping, or applying the herbicides imazapic at planting or clopyralid in the first season of growth. Initially, planting dates and management did influence the ability of Canada thistle to invade. However, after years of general prairie management across all treatments, the establishment methods studied are similar in many respects and Canada thistle populations and contribution to cover decreased to levels that no longer merit control. Data taken over time were discussed in past presentations. Novel findings from quadrat plant counts and % visual cover taken when each seeding was 7 years of age will be discussed in this presentation.

IMPACT OF CANADA THISTLE COVER ON PLANT COMMUNITY STRUCTURE IN EARLY STAGE PRAIRIE RESTORATION. Mary Halstvedt[1], Byron Sleugh*[2], Roger L. Becker[3], Paul Bockenstedt[4]; [1]Dow AgroSciences LLC, Billings, MT, [2]Dow AgroSciences, Indianapolis, IN, [3]University of Minnesota, St. Paul, MN, [4]Plant Iowa Native, St. Paul, MN (205)

Native tallgrass prairie historically included a mix of grasses along with native wildflowers. These ecologically important prairies provide food and shelter for a wide variety of wildlife species. Successful methods for seed harvest, site preparation, and planting have led to establishment of thousands of acres of reconstructed and restored high-diversity prairie each year. Although much has been learned, efforts to restore or reconstruct mixed wildflower (forb)-grass prairie landscapes are often compromised by the presence of invasive plants such as Canada thistle(*Cirsium arvense*). Results from this research demonstrate the impact of various cover levels of Canada thistle on the plant community in a reconstructed prairie. Data from previous research has shown that aminopyralid (Milestone® herbicide) is an effective tool in an integrated approach to managing invasive weeds while maintaining a desirable plant community at various stages of prairie restoration. Aminopyralid is a broadleaf herbicide that has an EPA reduced risk designation, and a high degree of selectivity towards many native forbs. Compared with other herbicides, these attributes make it a desirable alternative for invasive weed control on grasslands and prairie restorations.

CAN AMINOPYRALID BE APPLIED IN PRAIRIE ESTABLISHMENT WITHOUT IMPACTING NATIVE FORBS? Mark Renz, Niels A. Jorgensen*; UW-Madison, Madison, WI (206)

Herbicides, while effective and economical at suppressing invasive plants, can injure desirable plants. Previous research in Wisconsin and South Dakota showed that a one-time summer application of aminopyralid prior to fall dormant or spring seeding of common Midwestern forb species did not reduce establishment or persistence up to two years after treatment (YAT) compared to untreated controls. Several follow-up studies were conducted to further examine the interaction between herbicide application timing of aminopyralid and tolerance of native plants. The first study examined shortening the time frame between herbicide application of herbicide and seeding time. Two sites in Wisconsin were identified with known populations of Canada thistle (*Cirsium arvense*) and treated with aminopyralid (Milestone at 5 fl oz/A) in October prior to seeding, or in late June during planted species emergence. While there were initial differences in planted forb cover, counts and richness between treatments during the first year of establishment, by 2 YAT differences in overall forb cover did not differ at both locations. Another study investigated the impacts of aminopyralid (Milestone at 5 fl oz/A) on established forb populations when applied as a fall (October) or late spring (June) application. Spring applications were generally safer on forb populations than fall applications, but the response was species specific. Wild bergamot (*Monarda fistulosa*), golden Alexander (*Zizia aurea*), and smooth blue aster (*Symphyotrichum laeve*) were relatively tolerant to herbicide applications with <15% reduction in cover by two YAT. In contrast yellow coneflower (*Ratibida pinnata*) was more susceptible to both application timings of aminopyralid and showed reductions in cover that persisted two YAT. A final study was performed to investigate the community level response to a summer (early July) application of aminopyralid (Milestone 5 fl oz/A) in an established prairie in WI where Canada thistle was present. While cover of individual native species [rosinweed (*Silphium integrifolium*), heath aster (*Symphyotrichum ericoides*), and yarrow (*Achillea millefolium*)] were impacted by the application, total native forb cover in treated areas remained similar to untreated locations (50% cover) over the two-year period of study. Results from these studies highlight how to utilize aminopyralid for invasive plant control in prairies that are either planned or currently planted with common native forbs. While the response was species specific, in general limited long-term impacts (two YAT) were found with respect to most forbs evaluated. Studies in established prairies suggest that while sensitive forb species cover may be displaced, tolerant forbs increase cover to result in no differences in overall forb cover.

INDUSTRY AND NATURAL AREA MANAGER PARTNERSHIPS FOR PLANT COMMUNITY RESTORATION. Jeff Nelson*[1], Ernest S. Flynn[2], Byron Sleugh[3], Robert Masters[1]; [1]Dow AgroSciences, indianapolis, IN, [2]Dow AgroSciences, Lees Summit, MO, [3]Dow AgroSciences, Indianapolis, IN (207)

Aminopyralid has a well documented history of providing excellent long-term control of invasive and/or noxious species (*Cirsium arvense*, Centaurea spp., Cardus spp.) and safety on many desirable forb, semi-woody, and woody plant species. The adoption of Aminopyralid products (Milestone®, Capstone®) for restoration of degraded plant communities has been accelerated through key partnerships. These partnerships combine subject matter expertise throughout the academic community, Dow AgroSciences internal expertise, and the end-user, to effectively align the tools (aminopyralid products) to the vegetation management strategy. For example, multiple academic institutions (Colorado State, North Dakota State Univ., Univ. of Minnesota, etc). Government agencies, and Dow AgroSciences partnered to develop a comprehensive evaluation of forb tolerance to aminopyralid. Results from these studies are being leveraged by land managers to justify integrating aminopyralid in plant community restoration programs. Triclopyr products (Garlon® 4 Ultra and Garlon® 3A) are also being used for selective control of woody species. Dow AgroSciences continues to invest in sustaining and developing new partnerships to collaborate in developing new herbicide technology, for use in natural area management and plant community restoration programs.

PREVENTION AND CONTROL OF INVASIVE PLANTS: LESSONS LEARNED FROM FAMILY FOREST OWNERS IN INDIANA. Zhao Ma*, Mysha Clarke; Purdue University, West Lafayette, IN (208)

Invasive plants present significant threats to the health and functioning of forest ecosystems. The attitudes and behaviors of family forest owners are critical for controlling the spread of invasive plants. By analyzing data from semi-structured interviews and a survey of family forest owners in Indiana, we are able to assess forest landowners' awareness, attitudes, and behaviors towards invasive plants at the property and community scales, as well as the role of social influence in shaping their awareness, attitudes, and behaviors. Our results show that a majority of landowners are not aware of invasive plants and their impacts. Among those who are aware, few have taken actual measures on their property. Major reasons for inaction include lack of awareness and the financial cost and time commitment involved in prevention and control, as well as the differentiated perceptions of landowners towards invasion risk and management responsibilities across scales. Specifically, most landowners believe that individuals are responsible for controlling invasive plants on private properties, while the government is responsible for controlling on public lands. Some expressed disapproval of using legislation to force individuals to control invasive plants, while others expressed disapproval of using taxpayer money to control on private properties. Evidence suggests little potential for cooperation among Indiana landowners; instead, individual-based approach seems more plausible. Overall, our study points to a gap between family forest owners' perceived invasion risk and actual landscape-level invasion risk. Our results can inform the development of policy strategies for enhancing family forest owners' willingness and capacity to control invasive plants.

JOINING FORCES TO CONSERVE URBAN WOODLAND: ONE MODEL FOR CAMPUS, COMMUNITY AND COMMERCE COLLABORATIONS. Heather L. Reynolds*; Indiana University, Bloomington, IN (209)

No abstract submitted

PETITION TO RELEASE *CEUTORHYNCHUS SCROBICOLLIS* FOR BIOLOGICAL CONTROL OF GARLIC MUSTARD (*ALLIARIA PETIOLATA*). Roger L. Becker*[1], Elizabeth S. Katovich[1], Hariet L. Hinz[2], Laura C. Van Riper[3], Richard Reardon[4], Ghislaine Cortat[2], Mary E. Marek-Spartz[1]; [1]University of Minnesota, St. Paul, MN, [2]CABI Europe - Switzerland, Delémont, Switzerland, [3]Minnesota Department of Natural Resources, St. Paul, MN, [4]US Forest Service, Morgantown, PA (210)

Garlic mustard (Alliaria petiolata) is an invasive biennial plant native to Europe. In North America, garlic mustard poses a threat to regeneration of native herbaceous and woody plants in the forest understory. Updates on two of the most promising biological control insects, the European weevils Ceutorhynchus scrobicollis, a crown-miner, and Ceutorhynchus constrictus, a seed-feeder, have been presented in past NCWSS meetings. Finally, culminating efforts since 1998, we are positioned to submit our fourth, and final petition to APHIS to gain approval for release of C. scrobicollis. To date we have tested 111 species, within 23 families, including 7 endangered species one threatened species, plus 18 surrogates for threatened and endangered species. Eighty five species have been tested in the Brassicaceae family alone, comprising 20 tribes, and 35, 42, and 3 species in Brassicaceae lineage I, II, and III, respectively. Based on fundamental and realized host range testing, C. scrobicollis should be approved for release as the first biological control agent for control of garlic mustard in North Americas.

USING TECHNOLOGY TO REPORT INVASIVE SPECIES IN INDIANA VIA EDDMAPS AND THE GLEDN SMARTPHONE/TABLET APP. Rebekah Wallace*; Unversity of Georgia, Tifton, GA (211)

In 2005, the University of Georgia's Center for Invasive Species and Ecosystem Health (Bugwood) developed and launched EDDMapS, a web-based Early Detection and Distribution Mapping System, to accurately map distribution of invasive plants across the U.S. As smartphone technology has become ubiquitous, it is now possible for citizen scientists and other casual reporters to submit observations of invasive species in the field. State and regional programs have contributed existing bulk data to populate maps and they have also worked with Bugwood to develop websites and smartphone applications for their regional concerns. The list of species for each app has been tailored to common and emerging invasive species threats so that both casual and expert observers can effectively use the tool. The apps include identification information and images, current distribution maps, and a pared down reporting page for mapping point records in the field. New features for the apps include the ability to draw and map polygons and to map negative survey data. Polygons are useful in showing the shape and scope of an infestation and negative data will document areas that have been evaluated for invasive species.

IPC-CONNECT, A RESOURCE FOR INVASIVE SPECIES MAPPING AND MANAGEMENT IN THE MIDWEST. Steve Manning*; Invasive Plant Control Inc., nashville, TN (212)

No abstract submitted

MAPPING ECOLOGICAL RESTORATION EFFORTS IN THE SHAWNEE NATIONAL FOREST USING ESRI'S COLLECTOR APP. Caleb Grantham*, Nick Seaton; The Nature Conservancy, Makanda, IL (213)

No abstract submitted

STATE UPDATES ON SPREAD OF INVASIVE PLANTS - OHIO. Theresa Culley*; University of Cincinnati, Cincinnati, OH (214)

No abstract submitted

STATE UPDATES ON SPREAD OF INVASIVE PLANTS - INDIANA. Ellen Jacquart*; TNC Indiana, indianapolis, IN (215)

2015 was an extraordinary year in the fight against invasive species in Indiana. From a new reporting program (Report IN) to a draft rule that would prohibit the selling of highly invasive plants in the state to a brand new invasive plant brochure for the state, progress is being made. Hear the latest on these initiatives and other invasive news in Indiana.

STATE UPDATES ON SPREAD OF INVASIVE PLANTS - ILLINOIS. Karla L. Gage*; Southern Illinois University Carbondale, Carbondale, IL (216)

No abstract submitted

STATE UPDATES ON SPREAD OF INVASIVE PLANTS - WISCONSIN. Mark Renz*; UW-Madison, Madison, WI (217)

No abstract submitted

WHEN GOOD PLANTS GO BAD; MECHANISMS AND EFFECTS OF INVASION. Mike Jenkins*; Purdue University, West Lafayette, IN (218)

No abstract submitted

CONTROL OF CALLERY PEAR IN PASTURES, RIGHT-OF-WAYS, AND NATURAL AREAS. Ernest S. Flynn*[1], Reid J. Smeda[2], Carey F. Page[2]; [1]Dow AgroSciences, Lees Summit, MO, [2]University of Missouri, Columbia, MO (219)

Pyrus calleryana Dcne. (Rosales: Rosaceae), a native of Southeast Asia, was introduced to the U.S. in the early 1900's to confer fire blight resistance to common pear (*P. communis.*) via grafting. By the early 1950's the ornamental qualities of *P. calleryana* were recognized and led to the development of multiple cultivars, starting with Bradford in 1962. Today, cross pollination between fast growing and prolific flowering cultivars has created one of the most widespread, aggressive invaders of rights-of -way (ROW), natural areas, and pastures. Experiments were implemented in Missouri from 2012 through 2015 to evaluate herbicide options to control *P. calleryana*. The objectives of these studies were to: 1) determine the sensitivity to *P. calleryana* to aminopyralid-, triclopyr-, and picloram-containing products; 2) determine efficacy of low-volume basal bark (LVB) compared to foliar broadcast applications; and 3) determine efficacy when using either a non-ionic surfactant (NIS) or a methylated seed oil (MSO) as an adjuvant. Low-volume basal bark application with 25% Garlon® 4 Ultra + 75% basal oil was the most effective treatment, controlling 100% of treated trees. Surmount® (picloram + fluroxypyr) applied at 4 pints/acre was the most effective foliar application with control ranging from 70 to 85% when applied with a NIS (0.25% v/v) and 93% when applied with an MSO (1% v/v). Methylated seed oils improved efficacy of the GrazonNext® HL + Remedy® Ultra mixture and Surmount® but did not improve efficacy of Remedy® Ultra alone nor the Chaparral + Remdey® Ultra mix. Garlon® 4 Ultra, Capstone™, and Opensight® provided partial control of *P. calleryana* but follow-up applications will be required to achieve the desired level of control.

PRESCRIBED GRAZING FOR NON-NATIVE INVASIVE BRUSH CONTROL IN A MIDWEST HARDWOOD FOREST. Ron Rathfon*; Purdue University, Dubois, IN (220)

No abstract submitted

CAN THE INVASIVE TREE *AILANTHUS ALTISSIMA* BE TAMED WITH A NATIVE *VERTICILLIUM* FUNGUS? Joanne Rebbeck*, Joan Jolliff, Tim Fox; Northern Research Station, Delaware, OH (221)

The invasive tree *Ailanthus altissima* is widely distributed in the eastern U.S. It is allelopathic, a prolific wind-dispersed seeder, and displays aggressive clonal growth which can create dense thickets. Given its life history traits, traditional methods of control often fail. In 2003, the soil-born fungus, *Verticillium nonalfalfae*, was identified as the causal agent of large areas of dead and dying *Ailanthus* in Pennsylvania. Recently, the same fungus, native to North America, was isolated from dying Ailanthus in Virginia and Ohio. Pennsylvania researchers demonstrated that it selectively kills *Ailanthus* while not harming a wide range of native woody species. In 2013, we expanded the testing of this fungus in Ohio implementing greenhouse and field experiments to evaluate the susceptibility of Ohio seed sources of non-*Ailanthus* species to the fungus. In 2014, plots were established at five forested areas to characterize the response of stem-injected Ailanthus trees to the fungus; estimate its rate of spread; monitor for effects on non-target species; and assess the response of impacts on regenerating native and non-native vegetation. In 2015, 200 Ailanthus trees ranging from 15 to 40 cm diameter at breast height were inoculated with fungal spores. Within two weeks, treated trees began to wilt and senesce. After 16 weeks, 13% of these trees were dead and another 60% were severely defoliated (90-100% with epicormic sprouting) but no other species displayed symptoms. These preliminary findings corroborate our companion greenhouse inoculations of seedlings of oak, hickory, elm, ash and beech species in Ohio, as well as the >70 plant species tested in Pennsylvania. This native fungus shows great promise as a biocontrol agent of *Ailanthus* but further testing is needed to determine its safety. It has the added benefit of eliminating ecological concerns about introducing yet another non-native organism as a biological control agent.

INVASIVE PLANTS IN CITIES: A HISTORICAL PERSPECTIVE BASED ON THE FLORA OF INDIANAPOLIS. Rebecca Dolan*; Butler University, indianapolis, IN (222)

Recent reports cite an average of 28% of wild plants in cities world-wide are non-native. Many of these plants are invasive. At least 30 plants categorized as highly invasive by the Indiana Invasive Species Council have been reported for Indianapolis/Marion County, Indiana. How did they get here and how long have they been around? Using historical records, including early floras, published accounts and the Friesner Herbarium digital collection, I will trace the history of invasives in the city. Indianapolis' tale is likely representative of many cities in the Midwest and hopefully we can learn from history to help prevent future invasions. I will also touch on ecological and cultural impacts of invasive species in urban areas and highlight some successful control projects underway in Indianapolis.

HOW IMPORTANT ARE ORNAMENTAL CULTIVARS IN SPECIES INVASIONS? Theresa Culley*, Ilana Vinnik, Yulia Vinnik; University of Cincinnati, Cincinnati, OH (223)

No abstract submitted

THE MIDWEST INVASIVE PLANT NETWORK'S EFFORTS TO REDUCE THE SALE OF INVASIVE

ORNAMENTAL PLANTS. Mark J. Renz*; University of Wisconsin Madison, Madison, WI (224)

No abstract submitted

USE OF IMAZAPYR FOR OLD WORLD BLUESTEM CONTROL. Walter H. Fick*; Kansas State University, Manhattan, KS (225)

No abstract submitted

Old World Bluestems (OWB) (*Bothriochloa* spp.) have invaded native grasslands in Kansas and pose a major threat to the ecological integrity of our grassland systems. Cattle graze OWB little when given a choice on native rangeland. Studies were initiated in 2014 in Chase and Riley counties to determine the impact of varying rates of imazapyr on Caucasian bluestem and associated vegetation. Data were analyzed separately because of differences in management. The Chase County location was ungrazed and burned in 2014 and 2015. The Riley County site was burned in 2014 and grazed in 2014 and 2015. Treatments at both locations included 0.28, 0.56, 0.84, and 1.12 kg/ha imazapyr and an untreated check with four replications in a randomized complete block design. Herbicides were applied between June 10 and June 13, 2014 at the two locations using a CO_2-pressurized backpack sprayer. Individual plots were 2 x 7.6 m in size. Canopy cover, including OWB, warm-season grasses, cool-season grasses plus sedge, forbs, and woody species, was assessed at the time of treatment and one year after treatment (YAT) using four 0.25 m^2 frames per plot. Percent bare ground and litter were also estimated. Changes in cover were analyzed at the $P < 0.10$ using paired t-test. Increasing rates of imazapyr in Chase and Riley County decreased Caucasian bluestem. Warm-season grasses responded favorably in Chase County whereas forbs increased at the Riley County site. Above normal precipitation in May 2015 in Riley County and increased bare ground contributed to the increase in forbs such as annual broomweed. Imazapyr at 0.28 to 0.56 kg/ha can provide significant reduction of Caucasian bluestem with minimal damage to associated native grasses and forbs.

EFFECT OF MOWING TIMING ON JOHNSONGRASS HERBICIDE EFFICACY. Joe Omielan*, Michael Barrett; University of Kentucky, Lexington, KY (226)

Johnsongrass (*Sorghum halepense*) is a perennial warm season grass, listed as a noxious weed, and a common problem on right-of-way sites. There are a number of herbicides labeled and available to control johnsongrass and most rely on translocation from the leaves to the rhizomes for greatest efficacy. However, mowing is part of roadside management and one question is how does the timing of mowing after herbicide application affect efficacy? This study was initiated August 14, 2014 and repeated August 24, 2015 to answer the questions asked above at an interchange near Bardstown, KY. Four herbicide treatments were applied to 10 ft x 60 ft (3 m by 18 m) strips at 337 L/ha. Six time of mowing treatments were applied as 10 ft x 40 ft (3 m by 12 m) strips across the herbicide treatments in a split block design, replicated three times (four times in 2015). The herbicide treatments were Outrider (sulfosulfuron), Fusilade II (fluazifop), Acclaim Extra (fenoxaprop), and Fusilade + Acclaim. The time of mowing treatments were as follows: no mowing, same d as herbicide application, as well as one d, two d, one wk, and two wks after application. Visual assessments of percent johnsongrass control were done 34 (9/17/2014), 70 (10/23/2014), and 350 (7/30/2015) d after herbicide treatment (DAT) for the 2014 trial. Assessments were done 32 (9/25/2015), 45 (10/8/2015), and 53 (10/16/2015) DAT for the 2015 trial. In the 2014 trial, while Outrider had the lowest visual control (70%) without mowing 34 DAT it had the greatest control (83%) (compared to the other herbicide treatments) when mowed the same d as application. Outrider still had the greatest control (88%) when mowed the same d 70 DAT while the other herbicides ranged from 0 to 17% control. Control in the top set of treatment combinations ranged from 88 to 100% 70 DAT. Only the no mowing and two weeks after combinations with Acclaim Extra were in this top group. By 350 DAT control in the top set of treatment combinations ranged from 40 to 88%. Results from this trial suggest that mowing one or two days after application will not reduce the efficacy of Outrider, Fusilade, or Acclaim + Fusilade. However, one should wait one to two wks before mowing if Acclaim Extra was applied. Regrowth of johnsongrass after mowing was slower in 2015 than in 2014 with 89% control for the Outrider and Fusilade II treatments when mowed the same d 32 DAT and 81 to 85% control 53 DAT. Control for the other herbicide treatments mowed the same d ranged from 72 to 75% 53 DAT. Final assessments will be done in 2016.

THREE YEARS OF MOB GRAZING CAN REDUCE CANADA THISTLE POPULATIONS IN COOL SEASON GRASS PASTURES. Mark Renz*; UW-Madison, Madison, WI (227)

Canada thistle (*Cirsium Arvense*) has been identified as a problem weed in Wisconsin pastures. It can reduce forage yield and utilization which impacts animal performance. Our research compared the efficacy of a fall herbicide application, two mob grazing treatments (one and three consecutive years), and a rotationally-grazed control on Canada thistle and the resulting forage production and utilization. Research was conducted for three years at two sites in southern Wisconsin where effectiveness at suppressing Canada thistle was measured. At each site, paddocks were arranged in a randomized complete block design consisting of four replications. Aminopyralid + 2,4-D (120+970 g ae ha^{-1}) was applied the fall of 2011 as the herbicide treatment. Rotationally grazed treatments were grazed 3-4 times in each year (2012 – 2014) when forage was 20-36 cm and grasses were not flowering. Mob grazed plots were grazed twice when the sward was >36 cm, grasses were flowering, and Canada thistle was in the flower bud to flowering stage. All treatments were grazed to a 10 cm residual and allowed to recover until the specified height was reached. Stocking densities were 70 and 450 Mg/kg for the rotationally grazed and Mob treatments, respectively. Sites behaved differently therefore were analyzed separately. At Lancaster, a productive pasture with competitive legumes and forage grasses, the fall herbicide treatment provided nearly 100% Canada thistle suppression (cover and density) after one year. Nearly complete suppression from herbicide persisted for two years. In the third year cover and density increased but was < 50% of rotational grazing only treatments. Mob grazing and rotational grazing both had similar Canada thistle density and cover during the first two years, but by the third year Canada thistle cover and density was similar to herbicide applications. Rotational grazing treatments always had the highest stem density and cover throughout the experiment, with 87% more Canada thistle stems 3 years after completion of the study. In contrast, mob grazing stimulated Canada thistle populations at Prairie du Sac, a pasture with low production and no legumes, throughout the course of the study. Mob grazed plots averaged 2-8 times more Canada thistle stems throughout the course of the study. The one-time fall herbicide treatment did reduce Canada thistle for two years, but then recovered to similar levels as the rotationally grazed control after the third year. Conflicting results between sites make it difficult to recommend mob grazing for Canada thistle suppression. We believe that the presence of a robust and competitive pasture sward composition is a key factor responsible for Mob grazing's weed abatement success within the three-year timeframe that was evaluated. Other features of Mob grazing including utilization of lower palatability weeds such as Canada thistle are likely more important than weed management when selecting this management technique.

RESTORING FLORAL DIVERSITY TO NON-NATIVE GRASS-INFESTED SEDGE MEADOWS. Nathan Simons*; Blue Heron Ministries, Inc, angola, IN (228)

No abstract submitted

EFFECTS OF OVERABUNDANT DEER IN THE LOWER MIDWEST ON NATIVE BIODIVERSITY AND INTERACTIONS WITH INVASIVE SPECIES. Keith Clay*; Indiana University, bloomington, IN (229)

The density of white-tailed deer (*Odocoileus virginianus*) in many areas of the eastern U.S. is at record levels due to land use changes and extirpation of large predators. Overabundant deer can have negative effects on woody vegetation but less well understood are effects on other aspects of forest systems including interactions with invasive species. In a large southern Indiana forest preserve where deer densities were estimated by pellet counts to be over ten times higher than surrounding areas, we manipulated deer browsing by creating a series of 15 m x 15 m fenced exclosures over several years with an adjacent control plot of equal sizes. A series of vegetation and soil characteristics have been monitored annually in exclosure and paired control plots over multiple years. In the second experiment, we specifically evaluated how deer browsing and the presence of an invasive annual grass, *Microstegium vimineum*, affected the survival and growth of native tree seedlings in multiple sites where 1 m x 1 m plots were planted with one-year old tree seedlings. Half of each plot was fenced to prevent deer browsing and half of the plots had the invasive removed with a grass-specific herbicide in a split-plot design. In the large exclosure experiment, there was no recruitment of native tree seedlings in any control plots even while there was abundant tree seedling recruitment inside exclosures. Preexisting tree seedlings also grew faster inside exclosures, as did invasive shrubs, indicating that deer browsing was suppressing invasive shrubs. The mean height, diversity and density of spring ephemeral species were also higher in exclosures, and soils were less compacted than in control plots. In the second experiment with 1 m x 0.5 m exclosures, tree seedling survival was higher in plots where *Microstegium* was removed and in exclosure plots where deer browsing was prevented. Further, seedling biomass was greatest in exclosures where *Microstegium* was removed, but there was no effect of exclosure with *Microstegium* present. In total, our results suggest that deer browsing reduces tree seedling establishment and helps limit invasive shrubs.

UNDERPLANTING RESPONSE TO DEER HERBIVORY AND AMUR HONEYSUCKLE INVASION IN MIXED HARDWOOD FORESTS. Charlotte Freeman*, Mike Jenkins, Douglass Jacobs; Purdue University, West Lafayette, IN (230)

No abstract submitted

THE CASCADING EFFECTS OF INVASIVE ALIEN PLANTS ON THE STRUCTURE OF BELOWGROUND FOOD WEBS IN WOODLAND ECOSYSTEMS. Matthew McCary*; University of Illinois at Chicago, chicago, IL (231)

The proliferation of invasive alien plants into local ecosystems—a disturbance predicted to become even more severe in the 21st century—is a major threat to species diversity and ecosystem functioning on a global scale. To mitigate the impacts of invasive plants on ecosystem structure and biodiversity, a fundamental understanding of the mechanisms by which plant invaders alter ecological communities and networks is essential. This research evaluated the changes plant invasions can elicit to woodland arthropod food webs and communities. First, a meta-analysis of the primary literature was used to evaluate the impacts of invasive plants on the trophic structure of terrestrial ecosystems. Second, using a widespread invasive plant (*Alliaria petiolata* [garlic mustard]) as a model system, we evaluated a mechanistically based hypothesis of how garlic mustard alters belowground food webs via reduction of mycorrhizal fungi. Lastly, we investigated how the presence and/or removal of invasive plants restores the structure of arthropod communities in woodland ecosystems. Findings from the meta-analyses indicate that invasive plants have strong negative effects on primary consumers (detritivores, bacterivores, fungivores, and/or herbivores) in woodland ecosystems, which are less abundant in both green and brown food webs of invaded systems. Preliminary results from the manipulative field experiment with garlic mustard reveal no changes in arthropod primary- and secondary-consumer abundances in the first year of the invasive plant's life-cycle. However, the adult stage of garlic mustard (second year of this biennial species) alters composition of the fungivore community. Our "natural experiment", which was a collaborative study with the Chicago Wilderness Land Management Research Program, revealed that unmanaged woodland sites (i.e. sites with high densities of invasive plants) have a strikingly different community of ground-active arthropod detritivores and fungivores compared to high-quality restored (managed) sites, which have low densities of invasive plants. Overall, our findings indicate that invasive alien plants can engender considerable changes to the structure and composition of belowground food webs in woodland ecosystems. Nevertheless, these effects can be mediated by removing invasive plants and re-introducing native vegetation.

DO SOIL COMMUNITIES DIFFER BETWEEN NATIVE AND INVASIVE DUNE GRASSES ON GREAT LAKES SAND DUNES? Matthew L. Reid*, Sarah M. Emery; University of Louisville, Louisville, KY (232)

In Great Lakes sand dunes, the dominant dune-building grass is *Ammophila breviligulata*, which stabilizes mobile sand, initiating the dune-building process. In sand dunes, plant-soil interactions are critical drivers of successional change. In particular, plant-parasitic nematodes (PPN) contribute to the dieback of *Ammophila*, allowing other later-successional species to colonize. Arbuscular mycorrhizal fungi (AMF) are also important for dune succession, allowing plants to establish in low-nutrient dune soils. Invasive plants may cause shifts in belowground communities, potentially altering successional trajectories. A recent invader in this system is *Leymus arenarius*, a dune-building grass native to Europe. In a field survey, we assessed nematode community composition and AMF root colonization associated with each plant species. We found no differences between *Ammophila* and *Leymus* in terms of AMF root colonization, but nematode community composition showed differences with more bacteria-feeding nematodes associated with *Leymus*. Additionally, we tested for differences in dependence on and susceptibility to soil organisms of the native *Ammophila* and the exotic *Leymus*, by examining the effects of AMF and PPN on growth of both species in a greenhouse experiment. We manipulated presence/absence of AMF and PPN in a factorial design for each species and measured growth responses. Overall, *Leymus* was better protected than *Ammophila* from nematode root damage by AMF presence indicating that negative soil feedbacks due to buildups of PPN found in other dune successional systems may not apply when *Leymus* invades. These results provide evidence that changes to belowground community interactions may facilitate invasion by *Leymus* with potential consequences for successional dynamics.

PURPLE LOOSESTRIFE CONTROL WITH HERBICIDES: 10 YEARS OF APPLICATIONS. Stevan Z. Knezevic*, Jon E. Scott; University of Nebraska-Lincoln, Concord, NE (233)

No abstract submitted

PURPLE LOOSESTRIFE BIOLOGICAL CONTROL IN INDIANA. NINETEEN YEARS OF SUCCESS AND LIMITATIONS. Richard Dunbar*; Indiana Department of Natural Resources, Columbia City, IN (234)

The leaf eating beetles *Galerucella calmariensis* and *G. pussila* were first released in Indiana in 1994. There have been over 100 releases. *Galerucella* spp. have become naturalized and have been found over 10 miles (16 km) from the nearest know release site. The root mining weevil, *Hylobius transversovittatus* was first released in 2001. It has killed individual loosestrife plants. Its populations and spread have been difficult to monitor. The flower feeding weevil, *Nanophyes marmoratus*, was first released in 2002. They have naturalized and spread readily. Their effect of purple loosestrife populations is difficult to gauge. Purple loosestrife biological control has resulted in dramatic declines in large purple loosestrife population. It has controlled purple loosestrife on a scale that would not be practical through herbicide spraying. Herbicide may still be an appropriate choice for small populations in high quality natural areas.

FROM LAB TO LANDSCAPE: WHAT FACTORS AFFECT JAPANESE KNOTWEED CONTROL. Tony Summers*[1], Mark J. Renz[2]; [1]University of Wisconsin, Madison, WI, [2]University of Wisconsin Madison, Madison, WI (235)

Japanese knotweed (*Fallopia japonica*) is a nonnative invasive plant that has been identified as a problem in natural areas, urban environment, and rights of way. Asexual reproduction via rhizomatous spread and fragmentation result in dense stands that crowd out competing species and can cause structural damage. Japanese knotweed is difficult to control and anecdotal information exists claiming the relative efficacy of various treatment methods. Studies conducted between 2012 and 2015 compared the effectiveness of treating Japanese knotweed with 1) different chemicals at differing rates and timings, 2) varying the spray volume, 3) examining the effect of preexisting knotweed cover, and 4) timing and number of mowing prior to treatment. Herbicides evaluated included imazapyr (Arsenal), glyphosate (Rodeo), triclopyr + 2,4-D (Crossbow), and aminopyralid (Milestone). Results found that imazapyr (Arsenal at 4 - 5.25 pt/A) applied in the summer or fall to resprouting stems that were previously mowed provided the greatest reduction in Japanese knotweed that persisted longer (88% control 18 MAT) than other herbicides. Treatments of imazapyr were more effective when applied in July than in September. In contrast, applications of aminopyralid (milestone 7-14 fl oz/A) applied in September to resprouting stems provided 85%-92% control at 12 MAT but by 18 MAT % control was reduced to 15%-59%. Treatments with aminopyralid were more effective when applied in September (92% control) vs July (85% control) at 12 MAT. Research in 2013 confirmed the effectiveness of aminopyralid and found glyphosate (8 lb ae/A) applied at the same timing provided similar control 12 MAT. Subsequent studies also found that mowing was not required to give obtain similar control to treatments applied to resprouting stems mowed in July when applications of aminopyralid (milestone 14 fl oz/A) were applied in the fall at spray volumes between 20 and 100 gallons per acre 12 MAT. As multiple annual treatments are required for 100% control, the effect of the level of control 12 MAT had on subsequent treatments was evaluated. Studies across two locations found no relationship between cover of knotweed at the time of treatment and control 12 MAT when treated with aminopyralid (Milestone at 14 fl oz/A). This suggests plant cover at the time of treatment is not an important factor in the second year of treatment. While imazapyr was the most effective treatment it also resulted in a greater bare ground after treatment, as few species emerged after 12 MAT. These results suggest that Japanese knotweed can be controlled with herbicides, but treatments will need to be reapplied at least once. Site specific factors also need to be considered in selecting an appropriate herbicide.

ACHYRANTHES JAPONICA: A GROWING THREAT. David J. Gibson[1], Travis Neal*[2], Lauren Schwartz[3]; [1]Southern Illinois University Carbondale, Carbondale, IL, [2]southern Illinois University, carbondale, IL, [3]Southern Illinois University, carbondale, IL (236)

No abstract submitted

NORTHERN INDIANA COOPERATIVE INVASIVE MANAGEMENT (NICIM). (238)

No abstract submitted

LAKES COUNTRY CLUSTER. (237)

No abstract submitted

MONROE COUNTY - IDENTIFY AND REDUCE INVASIVE SPECIES. Ellen Jacquart*; TNC Indiana, Indianapolis, IN (239)

MC-IRIS formed in 2009 as an alliance of private landowners, agencies, land trusts, local businesses, and others to reduce the environmental and economic impact of invasive species in Monroe County through education and action. We put on an annual education event called Sustaining Nature And Your Land Day (SNAYL Day), have demonstration control events through the year, adopted and controlled local kudzu sites, developed a program called Go Green, Grow Native to encourage plant retailers to sell more native plants and less invasive plants, and more. Our group is a county member of SICIM (Southern Indiana Cooperative Invasives Management) and we work with them on grants and larger scale projects. We continue to grow and partner with other groups in our county on projects dealing with invasive species.

INTEGRATING PRESCRIBED FIRE AND INVASIVE SPECIES CONTROL ACROSS SOUTHERN ILLINOIS. Kevin Rohling*; RTR CWMA, carbondale, IL (240)

No abstract submitted

SOUTHERN INDIANA COOPERATIVE INVASIVE MANAGEMENT (SICIM). Elizabeth Mizell*; The Nature Conservancy, bloomington, IN (241)

Southern Indiana Cooperative Invasives Management or SICIM was organized in 2008 by a dedicated group of volunteers who saw the need to address invasives species in southern Indiana. SICIM covers 35 counties in southern Indiana and since its inception has worked tirelessly developing partnerships, providing invasive education/outreach, and assisting in the development of small local weed groups dedicated to addressing invasive species on a local level. Elizabeth Mizell who serves as SICIM's Secretary and as a Steering Committee Member will give an overview of SICIM and highlight two exciting projects the group has been developing during 2015.

BROWN COUNTY NATIVE WOODLANDS PROJECT. Ruth Ingraham*; Brown County Native Woodlands Project, indianapolis, IN (242)

BCNWP formed in 2006 after a few individuals shared their concern about the potential impact non-native invasive plant species could have on the biodiversity in our county, a mecca for tourists, artists and residents who are drawn to its scenic beauty. Education about invasives as well as natives is ongoing - through Nature Daze (a free, all day event), free landowner surveys, printed materials, newspaper articles and other means. Volunteers work sometimes single-handedly to eradicate species such as Japanese stilt grass, Japanese knotweed, and kudzu, to name a few. We maintain a strong partnership with The Nature Conservancy and Southern Indiana Cooperative Invasives Management, and work closely with local public representatives and private individuals.

INDIANA COASTAL COOPERATIVE WEED MANAGEMENT AREA. Susan MiHalo*; The Nature Conservancy, Merrillville, IN (243)

The mission of the Indiana Coastal Cooperative Weed Management Area (ICCWMA) is to strategically protect biodiversity and natural communities from the threats presented by invasive plants within the Lake Michigan Coastal Zone in Lake, Porter, and LaPorte Counties in Indiana. Natural areas here suffer greatly from fragmentation and multiple land uses. Nevertheless, this area also contains some of the most biodiverse parts of the state of Indiana. Formed in 2009, the ICCWMA has conducted several successful initiatives and projects in the past few years including: Restored 72 ha at Pine Station Nature Preserve and at several properties in Hobart, IN in 2012 as part of a jointly submitted Great Lakes Restoration Initiative proposal. Identified 85 existing and potential invaders to the area, including habitats where they can be found and 25 early detection species. Held an outreach event and roundtable discussion/focus group targeted to park employees and other stakeholders like the regional utility company NIPSCO. Developed a predictive model to help determine the potential for invasive species to invade several preserves in the Coffee Creek Watershed from surrounding areas. Trained ICCWMA members on using Site Weed Plans that helped map and prioritize invasive species. Held seven cooperative workdays, including an event to control sweet clover at Roxana Marsh that reduced infestations of that weed the following summer. Created banners depicting early detection and species that should not be planted that is used by ICWMA members for outreach. Incorporated cooperative workdays into several grant proposals of CWMA members to help those proposals stand apart The latest project being undertaken by the ICCWMA is to support the development of an early detection network in the area that will primarily focus on recruiting citizen science volunteers to monitor and report invasive species on EDDMaps. Data will be used by ICCWMA members to potentially justify future joint rapid response efforts and to help keep each other aware of species headed in our direction like Japanese stilt grass.

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Keyword Index

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