Proceedings of the 73nd Annual Meeting of the North Central Weed Science Society

December 3-6, 2018
Milwaukee, WI

The program and abstracts of posters and papers presented at the annual meeting of the North Central Weed Science Society are included in this proceedings document. Titles are listed in the program by subject matter with the abstract number listed in parenthesis. Abstracts are listed in numerical order followed by the author and keyword listing.

PROGRAM

General Session 2

POSTER SECTION 2

- **Agronomic Crops I – Corn** 2
- **Agronomic Crops II - Soybeans** 3
- **Agronomic and Specialty Crops (All other agronomic and horticultural crops)** 5
- **Equipment and Application Methods** 5
- **Extension** 6
- **Herbicide Physiology** 7
- **Invasive Weeds, Rangeland, Pasture, and Vegetation Management** 8
- **Weed Biology, Ecology, Management** 8

PAPER SECTION 9

- **Agronomic Crops I – Corn** 9
- **Agronomic Crops II- Soybeans** 10
- **Agronomic and Specialty Crops (All other agronomic and horticultural crops)** 12
- **Atmospheric Considerations for Making On-Target Herbicide Applications** 12
- **Essential Communication in Weed Science: Within and Beyond our Society** 13
- **Equipment and Application Methods** 13
- **Herbicide Physiology** 14
- **Invasive Weeds, Rangeland, Pasture, and Vegetation Management** 14
- **Making Data Meaningful: A Guide to Presnting Statistics at Scientific Meetings** 14
- **Weed Biology, Ecology, Management** 15

Abstracts 16

Author Index 108

Keyword Index 113

PROGRAM

2018 Officers/Executive Committee

President-Christy Sprague
President Elect- Aaron Hager
Vice President-Scott Howard
Past President-Greg Dahl
Secretary/Treasurer-David Simpson
Editor, NCWSS Proceedings-Greg Kruger
Editor, NCWSS Communications-Vince Davis
WSSA Representative-Greg Elmore
CAST Representative-Lowell Sandell
Executive Secretary-Kelley Mazur

General Session

Milwaukee, a Brief History. Steve Schaffer*; Milwaukee Historical Society, Milwaukee, WI (114)

Does a Liability Jury Decision Change the Toxicology of Roundup. Allan Felsot*; Washington State University, Richland, WA (115)

Presidential Address. Christy Sprague*; Michigan State University, E Lansing, MI (116)

Necrology Report. Cody Evans*; Monsanto, Murrayville, IL (117)

Announcements. Aaron Hager*; University of Illinois, Urbana, IL (118)

POSTER SECTION

***PRESENTER † STUDENT POSTER CONTEST PARTICIPANT**

Agronomic Crops I – Corn

Issues with Volunteer Corn Control in Dicamba-Tolerant Soybean. Jon E Scott*[1], O. Adewale Osipitan[2], Stevan Knezevic[3]; [1]University of Nebraska, Wakefield, NE, [2]University of Nebraska-Lincoln, Linconln, NE, [3]University of Nebraska, Wayne, NE (19)

†Herbicide Selection for Interseeding Cover Crops in Corn. Aaron P. Brooker*[1], Christy Sprague[2], Karen Renner[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (20)

†Influence of Cover Crop Selection on Weed Suppression and Subsequent Corn Yield in Semi-Arid Rainfed Cropping Systems of Western Nebraska. Italo Kaye Pinho de Faria*[1], Alexandre Tonon Rosa[2], Liberty E. Butts[3], Cody F. Creech[4], Roger Elmore[2], Daran Rudnick[1], Rodrigo Werle[5]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Scottsbluff, NE, [5]University of Wisconsin-Madison, Madison, WI (21)

†Impact of Wheat Stubble Management and Cover Crop Selection on Weed Demographics and Corn Productivity in Semi-Arid Cropping Systems of Western Nebraska. Alexandre Tonon Rosa*[1], Italo Kaye Pinho de Faria[2], Roger Elmore[1], Chuck Burr[2], Strahinja Stepanovic[3], Daran Rudnick[2], Cody F. Creech[4], Rodrigo Werle[5]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Grant, NE, [4]University of Nebraska-Lincoln, Scottsbluff, NE, [5]University of Wisconsin-Madison, Madison, WI (22)

†Influence of Crimson Clover and Cereal Rye Termination Timings on Corn Yield. Wyatt S. Petersen*, William G. Johnson; Purdue University, West Lafayette, IN (23)

Impact of Organic Herbicides in Corn. Betzy Valdez*, Kerry M. Clark, Reid Smeda; University of Missouri, Columbia, MO (24)

†Interactive Impact of Weed Removal Timing and Pre Herbicides on Growth and Yield of Corn. Ayse Nur Ulusoy*[1], O. Adewale Osipitan[2], Jon E Scott[3], Stevan Knezevic[4]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Nebraska-Lincoln, Linconln, NE, [3]University of Nebraska, Wakefield, NE, [4]University of Nebraska, Wayne, NE (25)

†Effects of Shading on Weed and Cover Crop Growth Parameters. Adam L. Constine*[1], Karen Renner[2], Aaron P. Brooker[1]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (26)

†Postemergence Control of Velvetleaf in Popcorn. Ethann R. Barnes*[1], Suat Irmak[1], Stevan Knezevic[2], Nevin C. Lawrence[3], Oscar Rodriguez[4], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Wayne, NE, [3]University of Nebraska, Scottsbluff, NE, [4]Conagra Brands, Inc, Brookston, IN (27)

A Short Course on Herbicide Modes of Action and Herbicide Resistance. Peter H. Sikkema*[1], Patrick Tranel[2], Thomas Mueller[3]; [1]University of Guelph, Ridgetown, ON, [2]University of Illinois, Urbana, IL, [3]University of Tennessee, Knoxville, TN (28)

Corn Ear Size as Influenced by Proximity to Winter Annual Weeds at Emergence and Side-dress Nitrogen Rate. Brent Heaton*[1], Mark L. Bernards[2]; [1]Western Illinois University, Industry, IL, [2]Western Illinois University, Macomb, IL (29)

Agronomic Crops II - Soybeans

WSSA Advocates for Weed Controls that Protect Soybean Export Value. Carroll M. Moseley*[1], Lee Van Wychen[2], Heather Curlett[3], Jill Schroeder[4], Patsy D. Laird[5], Shawn P. Conley[6]; [1]Syngenta Crop Protection, Greensboro, NC, [2]WSSA, Alexandria, VA, [3]APHIS-USDA, Washington, DC, [4]USDA Office of Pest Management Policy, Washington, DC, [5]Syngenta Crop Protection, LLC, Greensboro, NC, [6]University of Wisconsin-Madison, Madison, WI (37)

†Crop Safety of Preplant Applications of Halauxifen-Methyl on Soybean. Marcelo Zimmer*[1], Bryan G. Young[1], Bill Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, W Lafayette, IN (38)

Winter Annual Weed Control in Soybean with Haulaxifen-Methyl. Anthony F. Dobbels*, Mark Loux; The Ohio State University, Columbus, OH (39)

The Spatial and Temporal Distribution of Horseweed in Ohio Soybean Fields from 2013 to 2017. Alyssa Lamb*, Mark Loux, Bruce A. Ackley, Anthony F. Dobbels; The Ohio State University, Columbus, OH (40)

Alternative Sites of Action for Residual Control of Multiple-Resistant Horseweed in Soybeans. Bryan Reeb*, Mark Loux; The Ohio State University, Columbus, OH (41)

†Control of Glyphosate-Resistant Palmer Amaranth in Isoxafultole/Glufosinate-Resistant Soybean in Nebraska. Jasmine Mausbach*[1], Parminder Chahal[2], Kevin Watteyne[3], Amit Jhala[2]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Bayer CropScience, Lincoln, NE (42)

†Tillage Effects on Waterhemp Population Dynamics in Michigan. Scott R. Bales*[1], Christy Sprague[2]; [1]Michigan State University, east lansing, MI, [2]Michigan State University, E Lansing, MI (43)

†Importance of Residual Herbicides for Control of Glyphosate-Resistant Palmer Amaranth in Dicamba/Glyphosate-Resistant Soybean. Adam Leise*, Parminder Chahal, Ethann R. Barnes, Amit Jhala; University of Nebraska-Lincoln, Lincoln, NE (44)

Control of Palmer Amaranth with Preemergence Dicamba in Soybean. Dakota Came*, Marshall M. Hay, Dallas E Peterson; Kansas State University, Manhattan, KS (45)

†Weed Control and Response of Dicamba-Resistant Soybean to a Premix of Dicamba and Pyroxasulfone. Amy D. Hauver*[1], Ethann R. Barnes[2], Brady Kappler[3], Amit Jhala[2]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]BASF Corporation, Eagle, NE (46)

Weed Management Systems in Xtend Flex Soybean. Brian Stiles II*[1], Christy Sprague[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (47)

†Effect of Low Tank-Contamination Rates of 2,4-D and Dicamba on Sensitive Soybean Yield, Seed Viability, and Seedling Growth. Cade Hayden*[1], Julie Young[1], Jason K. Norsworthy[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]University of Arkansas, Fayetteville, AR (48)

†Screening of Soybean Variety Tolerance to PRE-Emergence Herbicides Sulfentrazone (PPO) and Metribuzin (PSII). Nikola Arsenijevic*[1], Sarah Striegel[2], Victor Hugo V. Ribeiro[2], Maxwel Coura Oliveira[2], Rodrigo Werle[2]; [1]University of Nebraska Lincoln, North Platte, NE, [2]University of Wisconsin-Madison, Madison, WI (49)

†Spectrum of Weed Species Controlled by Various PRE-Emergence Soybean Herbicides in Wisconsin. Victor Hugo V. Ribeiro*[1], Maxwel Coura Oliveira[1], Daniel Smith[2], Jose Barbosa dos Santos[3], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]UW Madison NPM, Madison, WI, [3]UFVJM, Diamantina, Brazil (50)

†Enlist One and Enlist Duo dose response on glyphosate tolerant and non-glyphosate tolerant soybeans. Estefania G. Polli*[1], Kasey Schroeder[1], Jeffrey Golus[1], Bruno Canella Vieira[2], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (51)

†Soybean Response to Timing of Rye Termination . Amin I. Rahhal*, Daniel L. Atherton, Mark L. Bernards; Western Illinois University, Macomb, IL (52)

†A Multi-State Survey of Tall Waterhemp Discovers a Broad Range of Sensitivity to PPO-Inhibiting Herbicides and Points to Mechanisms Other than the ∆G210 Target Site Mutation. Brent C. Mansfield*[1], Haozhen Nie[2], Julie Young[1], Kevin W Bradley[3], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, west lafayette, IN, [3]University of Missouri, Columbia, MO (53)

†Soybean Response to Simulated Dicamba Drift with Varying Application Rates and Timings. Tyler P. Meyeres*[1], Dallas E Peterson[2], Vipan Kumar[3]; [1]Kansas State University, Manahttan, KS, [2]Kansas State University, Manhattan, KS, [3]Kansas State University, Hays, KS (54)

Relative Sensitivity of Conventional Soybean to Dicamba Based Herbicides at Three Growth Stages. O. Adewale Osipitan[1], Jon E Scott*[2], Stevan Knezevic[3]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE (55)

Impact of Different Dicamba Herbicides on Glufosinate-Tolerant Soybean. O. Adewale Osipitan[1], Jon E Scott[2], Stevan Knezevic[3], Ayse Ulusoy*[4]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE, [4]University of Nebraska, Lincoln, NE (56)

Sensitivity of DT-Soybean to Micro-Rates of 2,4-D. O. Adewale Osipitan*[1], Jon E Scott[2], Stevan Knezevic[3]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE (57)

Response of Glyphosate-Tolerant Soybean to Dicamba Based Herbicides. O. Adewale Osipitan*[1], Jon E Scott[2], Stevan Knezevic[3]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE (58)

Effects of Dicamba Ultra Micro-Rates on Soybean Yield: Hormesis or Not? Stevan Knezevic*[1], Luka G. Milosevic[2], O. Adewale Osipitan[3], Jon E Scott[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska, Wakefield, NE (59)

Effects of Dicamba Ultra Micro-Rates on Soybean Growth. Stevan Knezevic[1], Luka G. Milosevic*[2], O. Adewale Osipitan[3], Jon E Scott[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska, Wakefield, NE (60)

Critical Time of Weed Removal in Glyphosate-Tolerant Soybean Across Three Locations in Nebraska. Stevan Knezevic*[1], Pavle Pavlovic[2], O. Adewale Osipitan[3], Ethann R. Barnes[4], Clint W. Beiermann[5], Nevin C. Lawrence[6], Jon E Scott[7], Amit Jhala[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]University of Nebraska-Lincoln, Scottsbluff, NE, [6]University of Nebraska, Scottsbluff, NE, [7]University of Nebraska, Wakefield, NE (61)

Extending Critical Time of Weed Removal in Dicamba-Tolerant Soybean with Residual Herbicides. Stevan Knezevic[1], Pavle Pavlovic*[2], O. Adewale Osipitan[3], Jon E Scott[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska, Wakefield, NE (62)

Control of Volunteer Glyphosate-Tolerant Alfalfa in No-Till Roundup Ready 2 Xtend and Enlist E3 Soybean. Lisa M. Behnken*[1], Fritz Breitenbach[1], Ryan P. Miller[2], Jamie Gehling[3]; [1]University of Minnesota Extension, Rochester, MN, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota Extension, Grand Meadow, MN (63)

†Injury and Symptomology Caused by Simulated Drift of Dicamba-Containing Herbicides on Soybean. Rosa Soriano*[1], Guilherme Sousa Alves[2], Jeffrey Golus[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (64)

†Influence of Application Timing, Surface Temperature Inversions, and New Formulations on Dicamba Air Concentrations Following Treatment. Shea T. Farrell*[1], Robert N. Lerch[2], Mandy Bish[1], Kevin W Bradley[1]; [1]University of Missouri, Columbia, MO, [2]USDA, Columbia, MO (65)

†Impact of Simulated Dicamba Drift on Sensitive Soybeans. Jerri Lynn Henry*[1], Jason Weirich[2], Reid Smeda[1]; [1]University of Missouri, Columbia, MO, [2]MFA Inc., Columbia, MO (66)

Herbicide Programs for Managing Glyphosate- and Dicamba-Resistant Kochia in Roundup Ready 2 Xtend Soybeans. Vipan Kumar*[1], Prashant Jha[2], Phillip Stahlman[1]; [1]Kansas State University, Hays, KS, [2]Montana State University, Huntley, MT (67)

†Influence of Wheat Cover Crop on Waterhemp Control in an Xtend Soybean System. Alexander Mueth*[1], Madison Decker[1], Karla L. Gage[1], Ron Krausz[2]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (68)

Agronomic and Specialty Crops (All other agronomic and horticultural crops)

Tolerance of Dry Bean to Herbicides Applied Preplant for Glyphosate-Resistant Horseweed Control in a Strip-Tillage Cropping System. Nader Soltani*, Christy Shropshire, Peter H. Sikkema; University of Guelph, Ridgetown, ON (1)

Response of Winter Wheat to Herbicide Plus Fungicide Plus Ammonium Thiosulphate Tankmixes. Nader Soltani*, David C. Hooker, Peter H. Sikkema; University of Guelph, Ridgetown, ON (2)

†Temporal and Varietal Impacts of Overseeded Cover Crops on Main Crop Yield and Winter Annual Weeds. Renee L. Adler*[1], Kelly Nelson[2]; [1]University of Missouri, Novelty, MO, [2]Univeristy of Missouri, Novelty, MO (3)

†Assessment of MultispeQ Photosynthetic Meter to Detect Herbicide Injury on Dry Bean. Justine Fisher*[1], Scott R. Bales[2], Christy Sprague[3]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, east lansing, MI, [3]Michigan State University, E Lansing, MI (4)

†Plant Growth Regulator Effects on Intermediate Wheatgrass-Weed Communities. Joseph W. Zimbric*, David E. Stoltenberg; University of Wisconsin-Madison, Madison, WI (5)

3D Models for Weed Identification Education. Bruce A. Ackley*; The Ohio State University, Columbus, OH (6)

Weed Control and Strawberry Response to Indaziflam. Sushila Chaudhari*, Katherine M. Jennings, Mathew Waldschmidt; North Carolina State University, Raleigh, NC (7)

Equipment and Application Methods

†Effect of Adjuvants on Physical Properties of Glyphosate and PPO-Inhibiting Herbicide Spray Mixtures. Jesaelen Gizotti de Moraes*[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (90)

†Physical Properties of Various Glyphosate Formulations as Critical Components for Commom Lambsquarters (*Chenopodium album* L.) Control. Milos Zaric*[1], Jesaelen Gizotti de Moraes[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (91)

Spray Drift from Dicamba in Tank-Mixtures with Adjuvants Sprayed Through Flat-Fan Nozzles. Guilherme Sousa Alves*[1], Bruno Canella Vieira[2], Greg R Kruger[1], Joao Paulo R. da Cunha[3]; [1]University of Nebraska, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]Federal University of Uberlandia, Uberlandia, Brazil (92)

†Comparison of Air Sampler Flow Rate and Filtration Media on Detecting Off-Target Movement of Dicamba. Tomas F. Delucchi*, Marcelo Zimmer, Julie Young, Bryan G. Young; Purdue University, West Lafayette, IN (93)

The Influence of Polymer Behavior and Pump Shear on Drift Reduction Adjuvants . Lee A. Boles*[1], Daniel C. Bissell[1], Annie D. Makepeace[2], Andrea Clark[3], Gregory K. Dahl[1], Ryan J. Edwards[4]; [1]Winfield United, River Falls, WI, [2]Winfield United, Shoreview, MN, [3]Winfield Solutions, LLC, River Falls, WI, [4]Winfield Solutions, River Falls, WI (94)

†Impact of Carrier Volume Rate on PRE-Emergence Herbicide Efficacy in Wisconsin Cropping Systems. Rachel Renz*[1], Sarah Striegel[2], Ryan P. DeWerff[3], Nikola Arsenijevic[4], Victor Hugo V. Ribeiro[2], Maxwel Coura Oliveira[2], Brian Luck[2], Rodrigo Werle[2]; [1]University of Wisconsin-River Falls, River Falls, WI, [2]University of Wisconsin-Madison, Madison, WI, [3]Agricultural Research of Wisconsin, LLC, Madison, WI, [4]University of Nebraska Lincoln, North Platte, NE (95)

†Influence of Spray Nozzle and Boom Height on Herbicide Drift. Catlin M. Young*[1], Travis R. Legleiter[2]; [1]Murray State University, Princeton, KY, [2]University of Kentucky, Princeton, KY (96)

†Interference of Clethodim on Glyphosate for Broadleaf Weed Control as Affected by Surfactant Adjuvants. Sofija Petrovic*[1], Isidor Ceperkovic[2], Kasey Schroeder[1], Jeffrey Golus[1], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Univeristy of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska, North Platte, NE (97)

†Grass Weed Control from Gyphosate and Clethodim Applications as Affected by Surfactants. Isidor Ceperkovic*[1], Sofija Petrovic[2], Jeffrey Golus[2], Kasey Schroeder[2], Greg R Kruger[3]; [1]Univeristy of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska, North Platte, NE (98)

†Interference of Clethodim on Glyphosate for Broadleaf Weed Control as Affected by Oil Based Adjuvants. Thais Uany de Souza*[1], Camila Chiaranda Rodrigues[1], Kasey Schroeder[1], Jeffrey Golus[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (99)

Influence of Tank Cleanout Products and Practices to Remove Dicamba from Commercial Spray Equipment.". David J. Palecek*[1], Ryan J. Edwards[2], Gregory K. Dahl[1], Joshua Skelton[3], Dustyn Sawall[4], Laura Hennemann[2], Andrea Clark[5], Lee A. Boles[1]; [1]Winfield United, River Falls, WI, [2]Winfield Solutions, River Falls, WI, [3]WinField United, River Falls, WI, [4]Ag Precision Formulators, Middleton, WI, [5]Winfield Solutions, LLC, River Falls, WI (100)

†Grass Weed Control from Gyphosate and Clethodim Applications as Affected by Oil Based Adjuvants. Camila Chiaranda Rodrigues*[1], Thais Uany de Souza[1], Jeffrey Golus[1], Kasey Schroeder[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (101)

†Spray Drift from Mesotrione and Isoxaflutole Through Different Nozzle Types. Andrea Rilakovic*[1], Guilherme Sousa Alves[2], Bruno Canella Vieira[3], Thalyson Medeiros de Santana[1], Rosa Soriano[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE, [3]University of Nebraska, Lincoln, NE (102)

†Particle Drift Potential from Dicamba-Containing Herbicides in a Wind Tunnel. Thalyson Medeiros de Santana*[1], Bruno Canella Vieira[2], Guilherme Sousa Alves[3], Andrea Rilakovic[1], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (103)

†Spray Particle Drift of Different Dicamba Formulations in a Wind Tunnel. Bruno Canella Vieira*[1], Guilherme Sousa Alves[2], Thalyson Medeiros de Santana[3], Camila Chiaranda Rodrigues[3], Vinicius Velho[3], Greg R Kruger[2]; [1]University of Nebraska, Lincoln, NE, [2]University of Nebraska, North Platte, NE, [3]University of Nebraska-Lincoln, North Platte, NE (104)

Extension

Detection and Frequency of Low Level Temperature Inversions in Minnesota. David Nicolai*[1], Jared J. Goplen[2], Ryan P. Miller[3], Andrew A. Thostenson[4]; [1]University of Minnesota, Farmington, MN, [2]University of Minnesota, Morris, MN, [3]University of Minnesota, Rochester, MN, [4]North Dakota State University, Fargo, MN (105)

The Influence of Preemergence Herbicides and Mechanical Incorporation on Cover Crop Establishment and Grain Yield in *Zea mays*. Lizabeth Stahl*[1], Ryan P. Miller[2], Jared J. Goplen[3], Lisa M. Behnken[4]; [1]University of Minnesota, Worthington, MN, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota, Morris, MN, [4]University of Minnesota Extension, Rochester, MN (106)

Farmer Survey Results Highlight Trends in Weed Management Practices. Lizabeth Stahl*[1], Lisa M. Behnken[2], Fritz Breitenbach[2], Ryan P. Miller[3], David Nicolai[4]; [1]University of Minnesota, Worthington, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota, Rochester, MN, [4]University of Minnesota, Farmington, MN (107)

†2018 Wisconsin Cropping Systems Weed Science Survey - Where are we at? Lina Liu*, Maxwel Coura Oliveira, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (108)

Herbicide Resistance in Wisconsin: An Overview. Joseph W. Zimbric*, David E. Stoltenberg, Mark Renz, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (109)

Demonstrating SOA Components of a Herbicide as an Extension Teaching Tool. Ryan P. Miller*[1], Lisa M. Behnken[2]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN (110)

†Assessment of Cover Crop Planting Date on Winter Annual Weed Suppression. Kolby R. Grint*, Christopher Proctor, Joshua S. Wehrbein; University of Nebraska-Lincoln, Lincoln, NE (111)

Use of Tableau to Visualize Invasive Plant Distribution in Wisconsin. Niels A. Jorgensen*[1], Mark Renz[2]; [1]University of Wisconsin, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI (112)

Survey of Nebraska and Wisconsin soybean producers on dicamba use during 2017 and 2018. Rodrigo Werle*[1], Christopher Proctor[2], Paul Mitchell[1], Amit Jhala[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Nebraska-Lincoln, Lincoln, NE (113)

Herbicide Physiology

†Expression Analysis of 12-Oxophytodienoic Acid Reductases in Response to Post-Emergence Cloquintocet-mexyl in *Triticum aestivum*. Olivia A. Obenland*, Kris N. Lambert, Dean E. Riechers; University of Illinois, Urbana, IL (8)

Physiological and Molecular Analysis of Glyphosate Resistance in Non-Rapid Response Giant Ragweed from Wisconsin. Courtney E. Wilson[1], Hudson K. Takano[2], Christopher R. Van Horn[2], Melinda Yerka[3], Phil Westra[4], David E. Stoltenberg*[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Colorado State University, Fort Collins, CO, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]Colorado State University, Ft Collins, CO (9)

†ACCase-Inhibitor and Growth Regulator Herbicides Applied in Tank Mixtures. Ely Anderson*[1], Kasey Schroeder[2], Jeffrey Golus[2], Thomas R. Butts[3], Bruno Canella Vieira[4], Andre de Oliveira Rodrigues[1], Bonheur Ndayishimiye[5], Greg R Kruger[1]; [1]University of Nebraska, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Arkansas, Lonoke, AR, [4]University of Nebraska, Lincoln, NE, [5]University of Nebraska-Lincoln, Lincoln, NE (10)

Glyphosate, Glufosinate, Dicamba and 2,4-D Applied in Tank-Mixtures on Glyphosate-Resistant, 2,4-D-Resistant and Susceptible Waterhemp Populations. Kasey Schroeder*[1], Barbara Vukoja[1], Bruno Canella Vieira[2], Jeffrey Golus[1], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (11)

†Efficacy of Trifludimoxazin, a New Protoporphyrinogen Oxidase-Inhibiting Herbicide, on PPO-Resistant Amaranthus Biotypes. Nicholas R. Steppig*[1], Samuel D. Willingham[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]BASF, Seymour, IL (12)

†Response of Atrazine-Resistant Palmer amaranth (*Amaranthus palmeri*) to PRE-Applied Atrazine. Dakota Came*[1], Junjun Ou[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Corteva Agriscience, Manhattan, KS (13)

†Efficacy of Glufosinate, Glyphosate and Dicamba Applied in Tank Mixtures. Rodger Farr*[1], Kasey Schroeder[1], Jesaelen Gizotti de Moraes[1], Jeffrey Golus[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (14)

Gene-Edited Acetolactate Synthase in Yeast and Response to Herbicides. Michael J. Christoffers*; North Dakota State University, Fargo, ND (15)

Molecular and Greenhouse Validation of Field-Evolved Resistance to Glyphosate and PPO-Inhibitors in Palmer Amaranth. Maxwel Coura Oliveira*[1], Darci Giacomini[2], Patrick Tranel[3], Gustavo De Souza Vieira[4], Nikola Arsenijevic[4], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Illinois, Urbana, IL, [3]University of Illinois, Urbana, IL, [4]University of Nebraska Lincoln, North Platte, NE (16)

A High-Quality Whole-Genome Assembly of Waterhemp (*Amaranthus tuberculatus*). Darci Giacomini*[1], Julia M. Kreiner[2], Bridgit Waithaka[3], Felix Bemm[3], Christa Lanz[3], Julia Hildebrandt[3], Julian Regalado[3], Peter Sikkema[4], John R. Stinchcombe[2], Stephen I. Wright[2], Detlef Weigel[3], Patrick Tranel[5]; [1]University of Illinois, Urbana, IL, [2]University of Toronto, Toronto, ON, [3]Max Planck

Institute for Developmental Biology, Tuebingen, Germany, [4]University of Guelph, Ridgetown, ON, [5]University of Illinois, Urbana, IL (17)

Association between Metabolic Resistances to Atrazine and Mesotrione in a Multiple-Resistant Waterhemp (Amaranthus tuberculatus) Population. Kip E. Jacobs*[1], Brendan V. Jamison[1], Rong Ma[2], Sarah R. O'Brien[3], Dean E. Riechers[2]; [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Illinois, Urbana, IL, [3]University of Illinois at Urbana-Champaign, Urban, IL (18)

Invasive Weeds, Rangeland, Pasture, and Vegetation Management

†*Amaranthus* Germination in Road Ditches: Potential Implications for the Spread of Palmer Amaranth. Cole Sigler*[1], Lauren Villafuerte[1], Manoj Rai[1], Clint Meyer[1], John Pauley[2]; [1]Simpson College, Indianola, IA, [2]Simpson college, Indianola, IA (30)

†Weed Species Diversity in Railroad Right-of-Ways. Andrew W. Osburn*, Mark Loux, Emilie Regnier, Kent Harrison; The Ohio State University, Columbus, OH (31)

Vastlan - A Novel Low Volatile Formulation of Triclopyr. David G. Ouse*[1], James Gifford[2], Byron Sleugh[2], Stephen Strachan[2], Dave Barenkow[2]; [1]Corteva agriscience, Indianapolis, IN, [2]Corteva, Indianapolis, IN (32)

PGR Options for Roadside Tall Fescue Management (2017-2018). Joe Omielan*, Michael Barrett; University of Kentucky, Lexington, KY (33)

***Generations*: Understanding Weed-Herbivore Interactions using Python.** Mary Marek-Spartz*[1], Kyle Marek-Spartz[2], George Heimpel[1], Roger Becker[3]; [1]University of Minnesota, St. Paul, MN, [2]Consultant, St. Paul, MN, [3]University of Minnesota, St Paul, MN (34)

Host Specificity of *Hadroplontus litura* on native *Cirsium* Species. Elizabeth Katovich*[1], Roger Becker[2], Mary Marek-Spartz[1]; [1]University of Minnesota, St. Paul, MN, [2]University of Minnesota, St Paul, MN (35)

Biological Control of Garlic Mustard: No Impact of *Ceutorhynchus scrobicollis* on Two Endangered Brassicaceae. Elizabeth Katovich*[1], Roger Becker[2], Mary Marek-Spartz[1], Laura Van Riper[3], Ghislaine Cortat[4], Hariet Hinz[4]; [1]University of Minnesota, St. Paul, MN, [2]University of Minnesota, St Paul, MN, [3]Minnesota Dept. of Natural Resources, Saint Paul, MN, [4]CABI, Delémont, Switzerland (36)

Weed Biology, Ecology, Management

†POST Herbicide Efficacy as Influenced by Severity of Waterhemp Injury from Prior Herbicide Applications. Jesse A. Haarmann*, Bryan G. Young, William G. Johnson; Purdue University, West Lafayette, IN (69)

†Apomixis or Auto-Pollination? Seed Production in Isolated *Amaranthus tuberculatus* Females. Brent P. Murphy*[1], Patrick Tranel[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL (70)

†Influence of Nitrogen Rate and Form on Palmer Amaranth Growth. Lindsey Gastler*, Anita Dille; Kansas State University, Manhattan, KS (71)

Waterhemp Seed Production and Viability Following Dicamba Application During Vegetative or Flowering Growth Stages . Allyson M. Rumler*[1], Brent Heaton[2], Mark L. Bernards[1]; [1]Western Illinois University, Macomb, IL, [2]Western Illinois University, Industry, IL (72)

†Dioecy in Amaranth: Why Are There Female-Specific DNA Sequences? Jacob S. Montgomery*[1], Ahmed Sadeque[1], Darci Giacomini[1], Patrick Brown[1], Patrick Tranel[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL (73)

†Time of Johnsongrass (*Sorghum halepense*) Seedling Emergence in Nebraska. Don G. Treptow*[1], Rodrigo Werle[2], Amit Jhala[3], Melinda Yerka[3], Brigitte Tenhumberg[1], John Lindquist[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska, Lincoln, NE (74)

Post-dispersal fate of Johnsongrass (Sorghum halepense) seeds in Nebraska. Don G. Treptow*[1], Rodrigo Werle[2], Amit Jhala[3], Melinda Yerka[3], Brigitte Tenhumberg[1], John Lindquist[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska, Lincoln, NE (75)

†The Weediness of Pollinator Habitat in Agricultural Field Borders 3 Years After Establishment. Samuel N. Ramirez*, David F. Barfknecht, Karla L. Gage; Southern Illinois University, Carbondale, IL (76)

†Role of cover cropping and herbicide use on marestail control: a regional perspective. Ryan J. Collins*, Erin Haramoto; University of Kentucky, Lexington, KY (77)

"Cover Crop Lite" Reduces Summer Annual Weed Density and Biomass in Soybean. Erin Haramoto*; University of Kentucky, Lexington, KY (78)

†Effects of Rye Termination Timings on Soybeans. Luke Chism*[1], Kraig Roozeboom[1], Gretchen Sassenrath[2], Anita Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Parsons, KS (79)

Influence of Management Decisions Relating to Cover Crops on Weed Suppression: A Meta-Analysis. O. Adewale Osipitan[1], Anita Dille*[2], Jon E Scott[3], Stevan Knezevic[4]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska, Wakefield, NE, [4]University of Nebraska, Wayne, NE (80)

†Characterizing Horseweed Emergence Patterns from Populations Across Four States. Larry J. Rains*[1], Karla L. Gage[2], Erin Haramoto[3], Reid Smeda[4], Anita Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Southern Illinois University, Carbondale, IL, [3]University of Kentucky, Lexington, KY, [4]University of Missouri, Columbia, MO (81)

Comparison of Fall and Spring Burndown Programs for Managing Glyphosate Resistant Horseweed in Soybeans. Kaity Wilmes*, Christopher Proctor, Amit Jhala; University of Nebraska-Lincoln, Lincoln, NE (82)

†The Interaction of Plant Cutting and Herbicide Application on Horseweed Control. Colton P. Carmody*[1], Ron Krausz[2], Karla L. Gage[1]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (83)

†Functional Diversity of Summer Cover Crop Mixes for Organic Transition Weed Suppression . Joseph Hamrock*, Emilie Regnier, Mark Loux; The Ohio State University, Columbus, OH (84)

†Efficacy of POST Applied Dicamba at Different Timings in RR2Xtend Soybean Systems in Wisconsin. Sarah Striegel*[1], Ryan P. DeWerff[2], David E. Stoltenberg[1], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Agricultural Research of Wisconsin, LLC, Madison, WI (85)

Effects of Tillage and Fertility on the Weed Seedbank over 49 Years in Southern Illinois. Sarah J. Dintelmann*[1], Ron Krausz[2], Karla L. Gage[1]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (86)

†Effects of Herbicide Management Practices on the Density and Richness of the Soil Seedbank in Dicamba and 2,4-D Resistant Cropping Systems in Indiana. Connor L. Hodgskiss*[1], Travis R. Legleiter[2], William G. Johnson[1]; [1]Purdue University, West Lafayette, IN, [2]University of Kentucky, Princeton, KY (87)

†Evaluation of Cereal Rye and Canola Termination Timing on Horseweed and Giant Ragweed Control. Stephanie DeSimini*, William G. Johnson; Purdue University, West Lafayette, IN (88)

†Impact of herbicide programs targeting pigweed species on grasses and large seeded broadleaves. Allen J. Scott*[1], Reid Smeda[1], Aaron Hager[2], Jason K. Norsworthy[3], Bryan G. Young[4]; [1]University of Missouri, Columbia, MO, [2]University of Illinois, Urbana, IL, [3]University of Arkansas, Fayetteville, AR, [4]Purdue University, West Lafayette, IN (89)

PAPER SECTION

***PRESENTER † STUDENT CONTEST PARTICIPANT**

Agronomic Crops I – Corn

†Efficacy of HPPD-Inhibiting Herbicides Applied Preemergence or Postemergence for Control of Multiple Resistant Waterhemp (*Amaranthus tuberculatus* var. *rudis*). Lauren Benoit*[1], Peter Sikkema[2], Darren Robinson[2], Dave Hooker[2]; [1]University of Guelph, Kirkton, ON, [2]University of Guelph, Ridgetown, ON (158)

Management of Glyphosate- and HPPD Inhibitor-Resistant Palmer amaranth in Corn. Vipan Kumar*[1], Rui Liu[1], Ednaldo A. Borgato[1], Phillip Stahlman[1], Pete Forster[2] [1]Kansas State University, Hays, KS, [2]Syngenta Crop Protection (159)

†Characterization of Two Multiple Herbicide-Resistant Waterhemp Populations from Illinois to Group 15 Herbicides. Seth Strom*, Lisa Gonzini, Charlie Mitsdarfer, Adam S. Davis, Dean E. Riechers, Aaron Hager; University of Illinois, Urbana, IL (160)

Predicting the Relative Long-Term Effectiveness of Herbicide Programs Using Syngenta's Resistance Fighter Model. R. Joseph Wuerffel*[1], Cheryl L. Dunne[1], Ethan T. Parker[1], Eric Palmer[2], Dane L. Bowers[2], Deepak Kaundun[3], Chun Liu[3]; [1]Syngenta Crop Protection, Vero Beach, FL, [2]Syngenta Crop Protection, Greensboro, NC, [3]Syngenta Crop Protection, Braknell, England (161)

†Control of Multiple Herbicide-Resistant Horseweed (*Conyza canadensis* L. *Cronq*.) and Waterhemp (*Amaranthus tuberculatus* var. *rudis*) with tolpyralate.. Brendan A. Metzger*[1], Nader Soltani[2], Alan J. Raeder[3], Dave Hooker[2], Darren Robinson[2], Peter Sikkema[2]; [1]University of Guelph - Ridgetown, Ridgetown, ON, [2]University of Guelph, Ridgetown, ON, [3]ISK Biosciences, Concord, OH (162)

Permeate: A New NPE-Free Non Ionic Surfactant with UV Protection. Thomas A. Hayden*[1], Gregory K. Dahl[2], Ryan J. Edwards[3], Jo A. Gillilan[4], Lillian c. Magidow[2], Joe V. Gednalske[2], Annie D. Makepeace[5]; [1]Winfield United, Owensboro, KY, [2]Winfield United, River Falls, WI, [3]Winfield Solutions, River Falls, WI, [4]Winfield United, Springfield, TN, [5]Winfield United, Shoreview, MN (163)

†Response of White and Yellow Popcorn Hybrids to Glyphosate, 2,4-D/Glyphosate, or Dicamba. Ethann R. Barnes*[1], Stevan Knezevic[2], Nevin C. Lawrence[3], Oscar Rodriguez[4], Suat Irmak[1], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Wayne, NE, [3]University of Nebraska, Scottsbluff, NE, [4]Conagra Brands, Inc, Brookston, IN (164)

Tankmixture of Gglyphosate with 2,4-D Accentuates 2,4-D Injury in Glyphosate-Resistant Corn. Peter Sikkema*, Christy Shropshire, Nader Soltani; University of Guelph, Ridgetown, ON (165)

†Control of Glufosinate/Glyphosate-Resistant Volunteer Corn in Enlist™ Corn. Adam Striegel*[1], Nevin C. Lawrence[2], Stevan Knezevic[3], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Scottsbluff, NE, [3]University of Nebraska, Wayne, NE (166)

Development of Robust FOPs and Synthetic Auxin Herbicide Tolerance Traits for GM Crops. Clayton Larue*, Michael Goley, Oscar C. Sparks, Christine Ellis, Marguerite J. Varagona; Bayer Crop Science, Chesterfield, MO (167)

†Critical Time of Weed Removal in Corn as Influenced by PRE-Herbicides. Ayse Nur Ulusoy*[1], O. Adewale Osipitan[2], Jon E Scott[3], Stevan Knezevic[4]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Nebraska-Lincoln, Linconln, NE, [3]University of Nebraska, Wakefield, NE, [4]University of Nebraska, Wayne, NE (168)

Interactions Between Residual Herbicides and Termination Timing in Cereal Rye on Summer Annual Weeds in Indiana Corn Systems. Wyatt S. Petersen*, William G. Johnson; Purdue University, West Lafayette, IN (169)

†Effects of Cover Crop Planting and Termination Time on Weed Demographics and Corn Productivity in Semi-Arid Rainfed Cropping Systems of Western Nebraska. Alexandre Tonon Rosa*[1], Italo Kaye Pinho de Faria[2], Liberty E. Butts[3], Cody F. Creech[4], Roger Elmore[1], Daran Rudnick[2], Rodrigo Werle[5]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Scottsbluff, NE, [5]University of Wisconsin-Madison, Madison, WI (170)

Weed Control in Corn with Increasing Levels of Irrigation With and Without a Wheat Cover Crop. Randall S Currie*, Patrick Geier; Kansas State University, Garden City, KS (171)

Agronomic Crops II- Soybeans

Benefits of Mesotrione in the Residual Control of ALS-Resistant Giant Ragweed in MGI Soybean. Benjamin C. Westrich*, Brent C. Mansfield, Bryan G. Young; Purdue University, West Lafayette, IN (145)

†Impact of PPO and PSII Soil-Applied Herbicides on Early Season Soybean Development and Grain Yield. Nikola Arsenijevic*[1], Matheus de-Avellar[2], Alexandre Tonon Rosa[3], Gustavo De Souza Vieira[1], Liberty E. Butts[1], Rodrigo Werle[4]; [1]University of Nebraska Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Wisconsin-Madison, Madison, WI (146)

Evaluation of Trifludimoxazin Alone and in Combination with Saflufenacil for Soil-Residual and Foliar Control of PPO Inhibitor-Resistant Tall Waterhemp. Nicholas R. Steppig*[1], Samuel D. Willingham[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]BASF, Seymour, IL (147)

†Do Planned Postemergence Herbicides Interact with Soybean Response to Off-Target Dicamba Exposure? Cade Hayden*, Bryan G. Young; Purdue University, West Lafayette, IN (148)

Waterhemp Management in West Central Ohio. Jeff M. Stachler*; The Ohio State University, Wapakoneta, OH (149)

†Utilizing Cereal Rye and Crimson Clover for Weed Suppression Within, and Outside of, Buffer Areas in Dicamba and 2,4-D Resistant Soybeans. Connor L. Hodgskiss*, William G. Johnson; Purdue University, West Lafayette, IN (150)

†Investigations of the Effects of Soil pH on the Volatility of Dicamba Formulations. Eric G. Oseland*, Mandy Bish, Kevin W Bradley; University of Missouri, Columbia, MO (151)

Waterhemp Resistant to Four Herbicide Sites of Action in Nebraska: Confirmation and Mechanism of Resistance. Debalin Sarangi*[1], Trey Stephens[2], Abigail Barker[3], Eric L. Patterson[3], Todd Gaines[3], Amit Jhala[2]; [1]Texas A&M University, College Station, TX, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Colorado State University, Fort Collins, CO (152)

†Evaluation of the Influence of Dicamba Exposure on Canopy Closure of Glufosinate-Resistant Soybean. Zachary K. Perry*[1], Madison D. Kramer[1], Travis R. Legleiter[2]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY (153)

Managing PPO-Resistant *Amaranthus* Sp. in Roundup Ready 2 Xtend® Soybeans. Neha Rana*[1], Rod Stevenson[2], Ryan E. Rapp[3], Blake R. Barlow[4], Alejandro Perez-Jones[1], Chenxi Wu[5]; [1]Bayer CropScience, Chesterfield, MO, [2]Bayer CropScience, plainwell, MI, [3]Bayer CropScience, Mitchell, SD, [4]Bayer CropScience, Columbia, MO, [5]Bayer CropScience, Urbana, IL (154)

†Critical Period of Parmer Amaranth Removal Affected by Pre-emergence Herbicides in Dicamba-Resistant Soybean. Jose H. Scarparo de Sanctis*[1], Stevan Knezevic[2], Vipan Kumar[3], Amit Jhala[4]; [1]Universito of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Wayne, NE, [3]Kansas State University, Hays, KS, [4]University of Nebraska-Lincoln, Lincoln, NE (155)

Control of Two *Amaranthus* Species in a Soybean Variety Tolerant to Glyphosate, Glufosinate, and Dicamba. Travis R. Legleiter*[1], J D Green[2]; [1]University of Kentucky, Princeton, KY, [2]University of Kentucky, Lexington, KY (156)

Dicamba Volatility from Plants vs. Soils. Donald Penner*[1], Jan Michael[2]; [1]Michigan State University, E Lansing, MI, [2]Michigan State University, East Lansing, MI (157)

†Organic Herbicides as a Weed Management Tool in Soybeans. Betzy Valdez*, Kerry M. Clark, Reid Smeda; University of Missouri, Columbia, MO (172)

Palmer Amaranth and Waterhemp Control with Integrated Strategies in Glufosinate-Resistant Soybean. Marshall M. Hay*, Anita Dille, Dallas E Peterson; Kansas State University, Manhattan, KS (173)

†Dicamba Simulated Tank-Contamination Injury from Post-Emergence Herbicide Applications on Non-Dicamba-Tolerant Soybean. Milos Zaric*[1], Bruno Canella Vieira[2], Guilherme Sousa Alves[3], Jeffrey Golus[1], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (174)

Effect of Row Spacing and Herbicide Programs on Glyphosate-Resistant Palmer Amaranth Control in Dicamba-Resistant Soybean in Nebraska. Parminder Chahal*[1], Carl W. Coburn[2], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer Crop Science, Gothenburg, NE (175)

†Response of Insect Pest and Beneficial Species to the Timing and Severity of Dicamba Injury in Soybean. William A. Tubbs*, Kevin Rice, Mandy Bish, Kevin W Bradley; University of Missouri, Columbia, MO (176)

Tolerance of Midwest Soybean Cultivars to Preemergent Applications of Metribuzin and Sulfentrazone. Thomas R. Butts*[1], Maxwel Coura Oliveira[2], Nikola Arsenijevic[3], Shawn P. Conley[2], Rodrigo Werle[2]; [1]University of Arkansas, Lonoke, AR, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska Lincoln, North Platte, NE (177)

†Integrating Fall-Seeded Cereal Cover Crops for Horseweed Management in No-Tillage Soybean. John A. Schramski*[1], Christy Sprague[2], Karen Renner[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (178)

What Not to do When Multiple Herbicide-Resistant Soybean Technology Coexist. Amit Jhala*; University of Nebraska-Lincoln, Lincoln, NE (179)

†Control of Annual Weeds in Isoxaflutole-Resistant Soybean. Andrea Smith*[1], Allan C. Kaastra[2], David C. Hooker[1], Darren Robinson[1], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Bayer CropScience, Guelph, ON (180)

Tavium™ Plus VaporGrip® Technology – A Tool for Weed Management in Conventional and No-Till Dicamba Tolerant Soybean. Aaron Franssen*[1], Brett Miller[2], Tom Beckett[3], Don Porter[3]; [1]Syngenta Crop Protection, Pleasant Dale, NE, [2]Syngenta Crop Protection, Fargo, ND, [3]Syngenta Crop Protection, Greensboro, NC (181)

EFAME - A New Class of EPA Approved Surfactants for Agricultural Use. Kevin Crosby*[1], Tim Anderson[2]; [1]Adjuvants Unlimited, LLC, Memphis, TN, [2]BASF, Cincinnati, OH (182)

Gramoxone Magnum: A New Option for Burndown and Residual Weed Control. Ryan Lins*[1], Adrian J Moses[2], Monika Saini[3], Dane L. Bowers[3]; [1]Syngenta Crop Protection, Rochester, MN, [2]Syngenta Crop Protection, Gilbert, IA, [3]Syngenta Crop Protection, Greensboro, NC (183)

A New Residual Herbicide for Dicamba-Tolerant Soybeans. Chad Asmus*[1], Kyle Keller[2]; [1]BASF Corporation, Newton, KS, [2]BASF Corporation, Raleigh, NC (184)

Engenia Herbicide Research Update. Chad Asmus*[1], Sanjeev Bangarwa[2]; [1]BASF Corporation, Newton, KS, [2]BASF Corporation, Raleigh, NC (185)

Agronomic and Specialty Crops (All other agronomic and horticultural crops)

†Dry Edible Bean Sensitivity to Reduced Rates of Dicamba and 2,4-D. Scott R. Bales*[1], Christy Sprague[2]; [1]Michigan State University, east lansing, MI, [2]Michigan State University, E Lansing, MI (186)

Crop Safety from Acifluorfen in Sugarbeet. Tom J. Peters*, Alexa L. Lystad, Nathan H. Haugrud; North Dakota State University, Fargo, ND (187)

†The Influence of Planting Date and Herbicide Program on Late Emerging Weeds in Dry Bean . Clint W. Beiermann*[1], Cody F. Creech[1], Amit Jhala[2], Stevan Knezevic[3], Robert Harveson[1], Nevin C. Lawrence[4]; [1]University of Nebraska-Lincoln, Scottsbluff, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska, Wayne, NE, [4]University of Nebraska, Scottsbluff, NE (188)

Axial Bold: The Next Step Up for Grass Control in Wheat and Barley. Brett Miller*[1], Pete C. Forster[2], Don Porter[3], Monika Saini[3]; [1]Syngenta Crop Protection, Fargo, ND, [2]Syngenta Crop Protection, Eaton, CO, [3]Syngenta Crop Protection, Greensboro, NC (189)

†Investigations of the Sensitivity of Various Tree and Ornamental Species to Driftable Fractions of 2,4-D and Dicamba. Brian R. Dintelmann*, Michele Warmund, Mandy Bish, Kevin W Bradley; University of Missouri, Columbia, MO (190)

Inter-row Cultivation Timing Effect on Sugarbeet Yield and Quality. Nathan H. Haugrud*, Tom J. Peters; North Dakota State University, Fargo, ND (191)

†Growth and Reproductive Response of Vidal Blanc Grapes to Dicamba. Sarah E. Dixon*, Reid Smeda; University of Missouri, Columbia, MO (192)

†Mapping of Genes Involved in Mesotrione Tolerance using BSR-Seq in Grain Sorghum. Balaji Aravindhan Pandian*, Vara Prasad PV, Sanzhen Liu, Tesfaye Tesso, Mithila Jugulam; Kansas State University, Manhattan, KS (193)

Atmospheric Considerations for Making On-Target Herbicide Applications

Atmospheric Conditions for On-Target Applications: Introduction. David Simpson*; Corteva Agriscience, Zionsville, IN (212)

A Fact Check of Temperature Inversion Understanding. Vernon Hofman*[1], Andrew A. Thostenson[2]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, Fargo, MN (213)

Navigating the Maze of Weather Data Sources and Avoiding Pitfalls. Dennis Todey*; USDA-ARS-NLAE, Ames, IA (214)

A Meterologist Perspective on Kansas Mesonet Inversions. Christopher Redmond*; Kansas State University, Manhattan, KS (215)

Temperature Inversion Findings from a Multi-State Weed Science Project. Kevin W Bradley*, Mandy Bish; University of Missouri, Columbia, MO (216)

What's Behind Smartphone Temperature Inversion Apps. Eric Snodgrass*; University of Illinois, Urbana, IL (217)

Ground-Truthing Smartphone Temperature Inversion and Wind Speed Apps. Joe Ikley*, William G. Johnson; Purdue University, West Lafayette, IN (218)

Regulatory Challenges of Interpreting & Documenting Wind Speed Language on Labels. Dave Scott*; Office of Indiana State Chemist, West Lafayette, IN (219)

Deposition and Dispersion of Spray Droplets in Normal Conditions. Jerome J. Schleier*; Corteva Agriscience, Indianapolis, IN (220)

Dispersion of Particles in Temperature Inversions. David Kristovich*[1], April Hiscox[2], Junming Wang[3]; [1]University of Illinois, Urbana, IL, [2]University of South Carolina, Columbia, SC, [3]ISWS, Prairie Research Institute, Champaign, IL (221)

Essential Communication in Weed Science: Within and Beyond our Society

Communications symposium introduction. Renee L. Adler*[1], Kelley D. Mazur[2]; [1]University of Missouri, Novelty, MO, [2]SWSS and NCWSS, Westminster, CO (194)

Importance of Communication in Agriculure - Industry. Janice Person*; Bayer Crop Science, St. Louis, IL (195)

Are Ad Hominem Arguments About Funding Sources Consistent with Skeptical Inquiry? Allan Felsot*; Washington State University, Richland, WA (196)

Communication Across Generations. Bader Rutter*; Bader Rutter, Milwaukee, WI (197)

Interactions with Agriculture Media. Pam Smith*; DTN/The Progressive Farmer, Decatur, IL (198)

Impact Statement Mini-Workshop. Heidi Zoerb*; University of Wisconsin-Madison, Madison, WI (199)

Equipment and Application Methods

New Findings on Ultra-Coarse Sprays and Test Methods. Daniel C. Bissell*[1], Chris Hogan[2], Bernard Olson[2], Lillian c. Magidow[1], Gregory K. Dahl[1], Joe V. Gednalske[1]; [1]Winfield United, River Falls, WI, [2]University of Minnesota, Minneapolis, MN (119)

Liquid LogicNew Sprayer Technology that Drastically Reduces the Time Required for Sprayer Cleanout and Solves Boom Priming Issues. Craig Jorgensen*; AGCO Corp, Jackson, MN (120)

Reducing Spray Drift and Increasing Spray Days with Redball-Hooded™ Sprayers - A Drift Comparison of a Redball-Hooded Boom Versus an Open Boom, and an Overview of Available Legal Spray Days in 2018. Steve W. Claussen*; Willmar Fabrication, LLC, Benson, MN (121)

†Spray Particle Drift Mitigation Using Field Corn as a Drift Barrier. Bruno Canella Vieira*[1], Thomas R. Butts[2], Andre de Oliveira Rodrigues[3], Jeffrey Golus[4], Kasey Schroeder[4], Greg R Kruger[3]; [1]University of Nebraska, Lincoln, NE, [2]University of Arkansas, Lonoke, AR, [3]University of Nebraska, North Platte, NE, [4]University of Nebraska-Lincoln, North Platte, NE (122)

Advanced Spray System Technology from John Deere. Yancy E. Wright*; John Deere, Shawnee, KS (123)

†Nozzle Selection and Adjuvant Impact on the Efficacy of Glyphosate and Glufosinate Tank-Mixed with PPO-Inhibiting Herbicides. Jesaelen Gizotti de Moraes*[1], Camila Chiaranda Rodrigues[1], Debora O. Latorre[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (124)

Large Scale Drift Trials to Assess Off-Target Movement of Dicamba. Greg R Kruger*[1], Guilherme Sousa Alves[1], Dan Reynolds[2], Bryan G. Young[3], Peter Sikkema[4], Christy Sprague[5], Rodrigo Werle[6], Jason K. Norsworthy[7], Ryan Rector[8]; [1]University of Nebraska, North Platte, NE, [2]Mississippi State University, Mississippi State, MS, [3]Purdue University, West Lafayette, IN, [4]University of Guelph, Ridgetown, ON, [5]Michigan State University, E Lansing, MI, [6]University of Wisconsin-Madison, Madison, WI, [7]University of Arkansas, Fayetteville, AR, [8]Bayer Crop Science, St. Charles, MO (125)

†Influence of Spray Nozzle Design and Weed Density on Herbicide Coverage and Deposition. Madison D. Kramer*[1], Zachary K. Perry[1], Travis R. Legleiter[2]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY (126)

Partitioning off-target movement of dicamba between particles and vaports: a first attempt. Greg R Kruger*[1], Guilherme Sousa Alves[1], Jeffrey Golus[2], Kasey Schroeder[2], Dan Reynolds[3], Darrin Dodds[4], Bradley K. Fritz[5], Clint Hoffmann[6], Ashli Brown

Johnson[7], Ashley Meredith[7]; [1]University of Nebraska, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Mississippi State University, Mississippi State, MS, [4]Mississippi State University, Starkville, MS, [5]USDA:ARS, College Station, TX, [6]Prology Consulting, College Station, TX, [7]Mississippi State Chemical Laboratory, Mississippi State, MS (127)

Redesigning HSMSO Adjuvants: Novel Terpene Polymer Containing Formulation. Patrick M. McMullan*[1], Mike Fiery[2]; [1]Ramulus LLC, Grimes, IA, [2]Miller Chemical & Fertilizer, LLC, Hanover, PA (128)

Compliance with Pesticide Labels on Spray Droplet Size and Carrier Rate to Maximize Pesticide Efficacy and Manage Spray Drift. Robert N Klein*; University of Nebraska, North Platte, NE (129)

Herbicide Physiology

†Dew Increases Dicamba Volatility from Soybean. Jerri Lynn Henry*, Reid Smeda; University of Missouri, Columbia, MO (200)

Palmer Amaranth and Kochia Impacts and Research in Colorado. Phil Westra*[1], Todd Gaines[2], Eric L. Patterson[2], Eric Westra[2], Neeta Soni[2], Olivia Todd[3]; [1]Colorado State University, Ft Collins, CO, [2]Colorado State University, Fort Collins, CO, [3]Colorado State University, Ft. Collins, CO (201)

†Herbicide Resistance Mechanisms Inform Herbicide Recommendations for Marestail Control. Sarah Miller*[1], Marisa DeForest[2], John Pauley[2], Clint Meyer[1]; [1]Simpson College, Indianola, IA, [2]Simpson college, Indianola, IA (202)

†Inheritance of Multiple Herbicide Resistance in Palmer Amaranth (*Amaranthus palmeri*). Chandrima Shyam*[1], Sridevi Nakka[1], Karthik Putta[1], Ivan B. Cuvaca[1], Randall S Currie[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS (203)

†Analysis of the Transcriptome Following 2,4-D Treatment in Susceptible and Tolerant Red Clover (*Trifolium pratense*) Lines. Lucas P. Araujo*[1], Michael Barrett[1], Linda D. Williams[1], Gene Olson[1], Randy Dinkins[2], Troy Bass[2]; [1]University of Kentucky, Lexington, KY, [2]USDA-ARS-FAPRU, Lexington, KY (205)

Invasive Weeds, Rangeland, Pasture, and Vegetation Management

Monitoring Garlic Mustard in Minnesota - Now You See Them, Now You Don't. Roger Becker*[1], Laura Van Riper[2], Lori Knosalla[3], Rebecca Montgomery[4], Mary Marek-Spartz[3], Elizabeth Katovich[3]; [1]University of Minnesota, St Paul, MN, [2]Minnesota Dept. of Natural Resources, Saint Paul, MN, [3]University of Minnesota, St. Paul, MN, [4]Universiy of Minnesota, St. Paul, MN (206)

†The Influence of Soil Fertility and pH on Pasture Weed Occurrence. Gatlin E. Bunton*, Kevin W Bradley; University of Missouri, Columbia, MO (207)

Housing Development Impacts on Herbicide Resistant Weed Pressure and Productivity Potential: a Case Study in Warren County, Iowa. Laken Baird*[1], Drew Roen[1], Clint Meyer[1], John Pauley[2]; [1]Simpson College, Indianola, IA, [2]Simpson college, Indianola, IA (208)

Control of Saltcedar Using Herbicides. Walter H. Fick*; Kansas State University, Manhattan, KS (209)

Field Validation of 15 Invasive Plant Ensemble Habitat Suitability Models in Wisconsin Using Citizen Science Observations. Niels A. Jorgensen*[1], Mark Renz[2]; [1]University of Wisconsin, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI (210)

Current Distribution, Suitable Habitat, and Control of Common Valerian (*Valeriana officinalis* L.) in Wisconsin. Mark Renz*[1], Niels A. Jorgensen[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin, Madison, WI (211)

Making Data Meaningful: A Guide to Presnting Statistics at Scientific Meetings

Making Data Meaningful: Introduction. Marty Williams*; USDA-ARS, Urbana, IL (222)

Critical Period of Weed Control. Stevan Knezevic*; University of Nebraska, Wayne, NE (223)

Weed Ecology. Anita Dille*; Kansas State University, Manhattan, KS (224)

Biologically Effective Dose. Stevan Knezevic*; University of Nebraska, Wayne, NE (225)

Molecular Weed Science. Patrick Tranel*[1], Darci Giacomini[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL (226)

Weed Biology, Ecology, Management

†Influence of Plant Growth Stage on Dicamba Efficacy to Control Palmer Amaranth. Ivan B. Cuvaca*[1], Randall S Currie[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS (130)

Effect of Different Defoliants/Desiccants on Seed Viability of Palmer Amaranth. Debalin Sarangi*[1], Kaisa M. Werner[1], Bojana Pilipovich[1], Peter A. Dotray[2], Muthukumar Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Lubbock, TX (131)

†Efficacy of Soybean Herbicide Respray Applications on Palmer Amaranth and Waterhemp. Jesse A. Haarmann*, Bryan G. Young, William G. Johnson; Purdue University, West Lafayette, IN (132)

Hindering Horseweed: An Integrated Approach for Soybeans in Kentucky. Austin D. Sherman*; University of Kentucky, Lexington, KY (133)

†Direct Comparisons of Sensitivity and Resistance to PPO Inhibitors in Waterhemp and Palmer Amaranth Populations. Kathryn Lillie*[1], Darci Giacomini[1], Patrick Tranel[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL (134)

†Do Varying Antioxidant Enzyme Levels Following a PPO Herbicide Application Help Explain the Resulting Variable Herbicide Response in Tall Waterhemp? Brent C. Mansfield*[1], Haozhen Nie[2], Yiwei Jiang[1], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, west lafayette, IN (135)

Overwintering of *Camelina sativa* Cultivars and Congeneric Species in the Northeastern US. Chuan-Jie Zhang*; University of Connecticut, Storrs, CT (136)

†Fomesafen Resistance in *Amaranthus retroflexus*. Brent P. Murphy*[1], Mark Loux[2], Bruce A. Ackley[2], Patrick Tranel[3]; [1]University of Illinois, Urbana, IL, [2]The Ohio State University, Columbus, OH, [3]University of Illinois, Urbana, IL (137)

Regional Perspective on Grain Sorghum Yield Losses Because of Weed Interference. Anita Dille*[1], Nader Soltani[2], Peter H. Sikkema[2], Phillip Stahlman[3], Curtis R Thompson[1]; [1]Kansas State University, Manhattan, KS, [2]University of Guelph, Ridgetown, ON, [3]Kansas State University, Hays, KS (138)

†Evaluation of waterhemp populations using 2,4-D, dicamba, mesotrione and imazethapyr. Estefania G. Polli*[1], Rosa Soriano[1], Julia Maria Rodrigues[1], Kasey Schroeder[1], Jeffrey Golus[1], Bruno Canella Vieira[2], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (139)

Impacts of Drought Tolerant Corn Hybrid Competition and Water Stress on Weed Community Composition and Corn Performance. Erin E. Burns*, Maninder Singh; Michigan State University, East Lansing, MI (140)

†Johnsongrass (Sorghum halepense) Demography in Nebraska. Don G. Treptow*[1], Rodrigo Werle[2], Amit Jhala[3], Melinda Yerka[3], Brigitte Tenhumberg[1], John Lindquist[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska, Lincoln, NE (141)

Evaluation of Canola and Cereal Rye Termination Timing on Crop Yield and Summer Annual Weed Control in the Eastern Cornbelt. Stephanie DeSimini*, William G. Johnson; Purdue University, West Lafayette, IN (142)

†Effect of Winter Annual Cover Crop Planting Date and Herbicide Program on Weed Suppression in Corn-Soybean Cropping Systems. Joshua S. Wehrbein*, Christopher Proctor; University of Nebraska-Lincoln, Lincoln, NE (143)

Abstracts

TOLERANCE OF DRY BEAN TO HERBICIDES APPLIED PREPLANT FOR GLYPHOSATE-RESISTANT HORSEWEED CONTROL IN A STRIP-TILLAGE CROPPING SYSTEM. Nader Soltani*, Christy Shropshire, Peter H. Sikkema; University of Guelph, Ridgetown, ON (1)

During 2016 and 2017, four field experiments were conducted at Huron Research Station in Exeter, Ontario to evaluate the sensitivity of dry beans, grown under a strip-tillage cropping system, to potential herbicides for the control of glyphosate-resistant (GR) horseweed. At 8 WAE, saflufenacil, metribuzin, saflufenacil + metribuzin, 2,4-D ester, flumetsulam, cloransulam-methyl, and chlorimuron-ethyl caused 13 to 32%, 8 to 52%, 32 to 53%, 5 to 7%, 13 to 21%, 16 to 29%, and 23 to 43% injury based on visual estimations in dry beans evaluated, respectively. Saflufenacil decreased biomass m^{-1} row 65% in kidney bean and 80% in white bean; metribuzin decreased biomass 82% in kidney bean and 50% in white bean; saflufenacil + metribuzin decreased biomass 88% in kidney bean, 68% in small red bean and 80% in white bean; and chlorimuron-ethyl decreased biomass 40% in white bean. There was no decrease in dry bean biomass m^{-1} row with the other herbicides evaluated. Metribuzin and saflufenacil + metribuzin reduced kidney bean seed yield 72 and 76%, respectively. Saflufenacil + metribuzin, flumetsulam, cloransulam-methyl and chlorimuron-ethyl reduced small red bean seed yield 39, 27, 30, and 54%, respectively. Saflufenacil, metribuzin, saflufenacil + metribuzin, flumetsulam, cloransulam-methyl, and chlorimuron-ethyl reduced seed yield of white bean 52, 32, 62, 33, 42, and 62%, respectively. There was no decrease in dry bean yield with the other herbicides evaluated. Among herbicides evaluated, 2,4-D ester caused the least crop injury with no effect in dry bean seed yield.

RESPONSE OF WINTER WHEAT TO HERBICIDE PLUS FUNGICIDE PLUS AMMONIUM THIOSULPHATE TANKMIXES. Nader Soltani*, David C. Hooker, Peter H. Sikkema; University of Guelph, Ridgetown, ON (2)

Co-application of herbicides with fungicides and foliar fertilizers can reduce application costs and increase input efficiency in winter wheat production. A study was conducted at six field sites near Exeter and Ridgetown, ON over a three-year period (2014, 2015 and 2016) to determine the effect of ammonium thiosulphate (ATS), various fungicides (azoxystrobin/propiconazole, trifloxystrobin/prothioconazole, or pyraclostrobin/metconazole), and various herbicides (bromoxynil/MCPA, thifensulfuron/tribenuron+MCPA, pyrasulfotole/bromoxynil, or 2,4-D/dichlorprop) applied alone and in tank mixture combinations on winter wheat crop injury and grain yield. The treatments were applied using Hypro ULD120-02 flat-fan nozzles around Zadoks Growth Stage 30. The herbicides and fungicides caused <0.6% leaf injury when ATS was not added to the tank mixture. When averaged across fungicides in ATS tank mixtures, leaf injury one week after application (WAA) was 3.5 to 3.7% with thifensulfuron/tribenuron and dichlorprop-P/2,4-D herbicides and 5.1 to 5.8% injury with bromoxynil/MCPA and thifensulfuron/tribenuron herbicides. On the three field sites with the highest leaf injury, a fungicide-ATS tank mixture increased injury to 4.5% averaged across fungicides, and to 4.3% with a herbicide-ATS tank mixture averaged across herbicides. Three-way tank mixtures of herbicide-fungicide-ATS caused the highest injury (7.1%). Despite significant crop injury one WAA with some tank mixtures, there was no evidence that grain yields were adversely affected. This study shows that the co-application of a three-way tank mixture of ATS with fungicides (azoxystrobin/propiconazole, trifloxystrobin/prothioconazole, or pyraclostrobin/metconazole) and herbicides (bromoxynil/MCPA, thifensulfuron/tribenuron+MCPA, pyrasulfotole/bromoxynil, or dichlorprop-P/2,4-D) has the potential to cause considerable injury in winter wheat under some environmental conditions in Ontario, but the effect seems transient with no grain yield reductions detected.

TEMPORAL AND VARIETAL IMPACTS OF OVERSEEDED COVER CROPS ON MAIN CROP YIELD AND WINTER ANNUAL WEEDS. Renee L. Adler*[1], Kelly Nelson[2]; [1]University of Missouri, Novelty, MO, [2]Univeristy of Missouri, Novelty, MO (3)

Field trials were established at the University of Missouri Greenley Research Center and Grace Greenley Farm near Novelty, MO from the spring of 2016 to the fall of 2018. Experiments were arranged in a randomized complete block design with 13 cover crop (CC) overseeding treatments in corn and 14 CC treatments in soybean with three to four replications in 3.1 by 12.2 m plots. Main crops (corn or soybean) were planted in the spring and rotated to the other crop the following year. Cover crops were broadcast overseeded into the main crop at three corn growth stages (V5, 10, VT) in separate experiments and one soybean growth stage (R6). The objective of this research was to determine the effect of CC (monoculture or blend) species for overseeding CC's into corn (stages) and soybean (stage) on cash crop yield, CC biomass, weed biomass, and rotational crop yield. No differences in plant population (PP), moisture, test weight (TW), or yield were detected in corn or the subsequent soybean crop when corn was overseeded at V5. Neither CC nor weed biomass was greater than the non-treated control (NTC). Year by treatment interactions were present for CC biomass and subsequent soybean yield when corn was overseeded at V10. In 2017, CC biomass was 390 to 920 kg ha^{-1} greater than NTC and Dixie increased soybean yield 490 kg ha^{-1}. Red clover reduced corn yield 760 kg ha^{-1} in 2017 when overseeded at VT. Biomass of CC's overseeded into soybean at R6 was 2510 to 3310 kg ha^{-1} greater in 2017 than in 2018 and some CC's reduced weed population in 2017. Cover crops reduced corn yield 1800 to 3590 kg ha^{-1} and PP following overseeded soybean. In all timings and crops, excluding wheat, CC treatments did not reduce cash crop yield in 2018. This suggests that lower CC biomass may reduce yield loss of rotational crops caused by CC's. Earlier springtime termination of CC's might prevent excessive biomass accumulation and detrimental effects on yield and stand establishment of corn.

ASSESSMENT OF MULTISPEQ PHOTOSYNTHETIC METER TO DETECT HERBICIDE INJURY ON DRY BEAN. Justine Fisher*[1], Scott R. Bales[2], Christy Sprague[3]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, East Lansing, MI, [3]Michigan State University, E Lansing, MI (4)

Crop injury from herbicides continues to be a concern for growers. Crops can be exposed to herbicides from either direct applications or off-target movement. Visual control evaluations are often used to assess crop injury from herbicides. Herbicide symptomology can be observed on crops anywhere from one to seven d after application, depending on the herbicide. MultispeQ is a new type of photosynthetic meter that measures over ten different parameters ranging from leaf temperature to non-photochemical quenching. In 2018, a greenhouse study was conducted in East Lansing, Michigan to evaluate MultispeQ as a possible tool to assess herbicide injury to dry edible beans. 'Zenith' black beans at the V2 growth stage were treated with herbicides from six different site of action groups. Treatments included the labeled dry bean herbicides: 1) fomesafen (Group 14) at 280 g ha^{-1} + crop oil concentrate 2) bentazon (Group 6) at 840 g ha^{-1} + crop oil concentrate and 3) imazamox (Group 2) at 35 g ha^{-1} + crop oil concentrate + ammonium sulfate. Sub-lethal rates of dicamba (Group 4) at 11 g ha^{-1}, glyphosate (Group 9) at 25 g ha^{-1}, and atrazine (Group 5) at 70 g ha^{-1} + crop oil concentrate were also applied to mimic injury from off-target applications. MultispeQ measurements were taken at 6 h, and 1, 3, 7, and 14 d after treatment (DAT) on center leaf of the second trifoliate. Dry beans were evaluated for injury 1, 3, 7, and 14 DAT. Plant height, trifoliate counts, and aboveground biomass was harvested 14 DAT. At 7 DAT, average injury from labeled dry bean herbicide treatments was 8%. Dry bean injury from dicamba, atrazine, and glyphosate was 71, 14, and 1%, respectively. Plant height, trifoliate counts, and aboveground biomass 14 DAT reflected herbicide injury. At 7 DAT, the MulitspeQ meter only detected differences in dry beans treated with bentazon and atrazine with the photosystem II (Phi2), non-photochemical quenching (NPQt), and PhiNO and PhiNPQ (measurements of light not used for photosynthesis) parameters. NPQt and PhiNPQ decreased rapidly in dry beans treated with bentazon, as plants recovered from initial injury. By 7 DAT, atrazine was the only treatment where NPQt levels were different from the untreated plants; as well as the lowest Phi2, PhiNO, and relative chlorophyll levels. Atrazine also had the highest PhiNPQ levels at 27%. Relative chlorophyll levels were highly variable and did not correspond to crop injury ratings for any of the treatments. The MultispeQ platform was able to detect herbicide injury; however, its potential to measure herbicide injury and detect differences was only found with the photosystem II inhibitors, atrazine and bentazon.

PLANT GROWTH REGULATOR EFFECTS ON INTERMEDIATE WHEATGRASS-WEED COMMUNITIES. Joseph W. Zimbric*, David E. Stoltenberg; University of Wisconsin-Madison, Madison, WI (5)

Intermediate wheatgrass (*Thinopyrum intermedium*) is a cool-season perennial species that has been the focus of extensive plant breeding efforts to improve several agronomic traits, the results of which have contributed to an increasing market demand for its grain, Kernza®. However, lodging has been reported to reduce intermediate wheatgrass grain yield in some environments. To address this problem, research was conducted to determine the effects of the commercially-available (but not labeled for use on intermediate wheatgrass) plant growth regulator, trinexapac-ethyl (TE), on intermediate wheatgrass lodging, height, and grain yield, as well as weed suppression in dual-use (forage and grain) production systems. We hypothesized that TE would decrease intermediate wheatgrass height and protect grain yield potential, but would potentially decrease weed suppression. The experiment was established in the fall of 2015 at the University of Wisconsin-Madison Arlington Agricultural Research Station using Cycle 4 intermediate wheatgrass. The experimental design was a randomized complete block with three replications of four forage harvest timings (spring, summer, and fall; summer only; summer and fall; no harvest), two nitrogen application rates (90 and 135 kg N ha^{-1}), two TE rates (0.22 and 0.66 kg ai ha^{-1}), and weedy and weed-free control treatments. Treatments were imposed in 2017 and 2018 during the second and third production years, respectively. Dandelion (*Taraxacum officinale* F.H. Wigg.) and annual fleabane [*Erigeron annuus* (L.) Pers.] were the most abundant weed species in both years. Weed shoot biomass across treatments and years was 6.5-fold greater in the weed check (213 kg ha^{-1}) compared to the weed-free treatment (33 kg ha^{-1}). Intermediate wheatgrass lodging was not observed in 2017 or 2018 at the time of grain harvest; however, plant height was 10 and 14% less in TE treatments compared to control treatments in 2017 and 2018, respectively. Intermediate wheatgrass grain yield did not differ among forage harvest treatments in 2017, but was greater with the inclusion of a forage harvest treatment compared to the no forage harvest treatment in 2018. In 2017, grain yield was greater in the high N treatment than in the low N treatment, but was not affected by N treatment in 2018. Total aboveground weed shoot dry biomass across treatments was less in 2018 compared to 2017, but did not differ among forage harvest treatments, nitrogen levels, or TE treatments in either year. These findings suggest that TE can be used to reduce intermediate wheatgrass plant height and the risk of lodging, while protecting grain yield potential and maintaining effective weed suppression.

3D MODELS FOR WEED IDENTIFICATION EDUCATION. Bruce A. Ackley*; The Ohio State University, Columbus, OH (6)

Virtual images provide a new way to use an old tool - visualization - in the world of weed science. Detailed interactive images have the possibility to someday replace live specimens in the arena of weed identification, along with the possibility of enhancing other educational goals, especially when teaching online or at distance.

WEED CONTROL AND STRAWBERRY RESPONSE TO INDAZIFLAM. Sushila Chaudhari*, Katherine M. Jennings, Mathew Waldschmidt; North Carolina State University, Raleigh, NC (7)

The investigation of potential herbicides for weed control in strawberry is critical due to the limited number of registered herbicides and with the evolution of herbicide-resistant weeds. Therefore, two field studies (tolerance and weed control) were conducted during 2017-2018 at the Piedmont Research Station, Salisbury, NC to determine the effect of indaziflam rate and application timing on strawberry tolerance and weed control. In both studies, treatments included indaziflam PREPLANT at 36.5, 73, 110, and 146 g ai ha^{-1} applied one wk before strawberry transplanting (WBT), indaziflam POST at 36.5 and 73 g ai ha^{-1} applied 15 or 20 wk after strawberry transplanting (WAT), and a non-treated (tolerance study) or season long weed-free and weedy (weed control study) checks. The tolerance study was maintained weed-free throughout the season. In both studies, indaziflam PREPLANT caused foliar stunting and chlorosis. At 23 WAT, crop stunting ranged from 16 to 50% and 36 to 58% and chlorosis ranged from 8 to 19% and 11 to 23% in the tolerance and weed control study, respectively. However, in both studies indaziflam POST caused <4% crop stunting or chlorosis regardless of application rate or timing. In the tolerance study, indaziflam PREPLANT reduced marketable yield by 11 to 50% compared to the non-treated check; but no yield reduction was observed from indaziflam POST. In the weed control study, indaziflam PREPLANT provided excellent season-long control of curly dock (100%), common chickweed (100%), Carolina geranium (100%), and henbit (≥76%). However, marketable yield was reduced by 29 to 52%. Indaziflam-POST did not cause any crop injury, but marketable yield was reduced 7 to 45% because of lack of weed control.

EXPRESSION ANALYSIS OF 12-OXOPHYTODIENOIC ACID REDUCTASES IN RESPONSE TO POST-EMERGENCE CLOQUINTOCET-MEXYL IN *TRITICUM AESTIVUM*. Olivia A. Obenland*, Kris N. Lambert, Dean E. Riechers; University of Illinois, Urbana, IL (8)

Safeners are chemical compounds that protect large-seeded cereal crops from herbicide injury by inducing metabolic detoxification reactions of herbicides. For cultivated bread wheat (*Triticum aestivum*), safeners are of particular importance to achieve crop tolerance since the creation of genetically modified cultivars for herbicide tolerance is not desirable due to risk of transgene flow to weedy relatives. While safeners have been prevalent in agriculture for decades and their phenotypic effects are well documented, knowledge of signaling pathways induced by safeners is still severely limited. One theory is that safeners may be exploiting plant hormone signaling pathways to induce the expression of genes involved in herbicide metabolism, such as cytochrome P450-dependent monooxygenases, glutathione S-transferases, and ATP-binding cassette transporter proteins. Since previous studies showed that genes encoding 12-oxophytodienoic acid reductases (OPRs), enzymes involved in jasmonate (JA) biosynthesis, exhibited increased expression after exposure to stress and safener treatments, our current hypothesis is that safeners utilize a JA-mediated signaling pathway to induce the expression of genes involved in herbicide metabolism. The objectives of this study are to (1) identify TaOPR genes that respond to foliar applications of the safener, cloquintocet-mexyl, in wheat seedlings via RT-qPCR, and (2) determine differences in expression of these TaOPR genes among three different tissues (shoot meristematic region as well as the proximal and distal portions of the first true leaf) and three time points after safener application (3, 6 and 12 hours after treatment (HAT)). A TaOPR gene located on the long arm of chromosome 6D (TaOPR6DL) displayed high expression levels in all safener-treated tissues relative to unsafened controls, with an approximate 100-fold induction in the shoot meristematic region. Fold inductions for the TaOPR genes on the short arm of 2B (TaOPR2BS; 20-fold) and the long arm of 7D (TaOPR7DL; 6-fold) were not as high as TaOPR6DL. The highest fold inductions for all genes were observed at 6 HAT but were transient in nature, as evidenced by lower fold inductions at 12 HAT. Since cloquintocet-mexyl is a prosafener, it is possible that bioactivation of the parent ester and translocation of the free acid may influence these expression patterns in wheat leaves. While these results support the hypothesis that safeners induce the expression of certain TaOPRs, further analysis is needed to determine whether TaOPR6DL is required for JA biosynthesis or oxidized lipid-mediated signaling, and if its expression is required to achieve herbicide tolerance in wheat.

PHYSIOLOGICAL AND MOLECULAR ANALYSIS OF GLYPHOSATE RESISTANCE IN NON-RAPID RESPONSE GIANT RAGWEED FROM WISCONSIN. Courtney E. Wilson[1], Hudson K. Takano[2], Christopher R. Van Horn[2], Melinda Yerka[3], Phil Westra[4], David E. Stoltenberg*[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Colorado State University, Fort Collins, CO, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]Colorado State University, Ft Collins, CO (9)

Evolved herbicide resistance in giant ragweed (*Ambrosia trifida* L.) has increased management challenges associated with this highly-competitive summer annual species and has likely contributed to the expansion of its native range in North America. We previously identified a glyphosate-resistant giant ragweed population in Wisconsin that showed a non-rapid response to glyphosate. Our objective was to determine the role of glyphosate non-target-site resistance and target-site resistance mechanisms in this phenotype. Whole-plant dose-response experiments showed a 6.5-level of glyphosate resistance for the resistant (R) phenotype compared to a susceptible (S) phenotype. Absorption and translocation of 14C-glyphosate were similar between R and S phenotypes over a 72-h time course. Concentrations of glyphosate and aminomethylphosphonic acid in leaf tissue did not differ between R and S phenotypes over a 96-hr time course. In vivo shikimate leaf disc assays showed that glyphosate EC_{50} values (the effective concentration that increased shikimate accumulation 50% relative to non-treated leaf tissue) were 4.6- to 5.4-fold greater for the R than S phenotype. However, at high glyphosate concentrations (>1,000 µM), shikimate accumulation was similar between phenotypes, suggesting that resistance is not likely due to an altered target site (5-enolpyruvylshikimate-3-phosphate synthase, EPSPS). This finding was supported by results showing that EPSPS copy number and EPSPS abundance did not differ between R and S phenotypes, nor did EPSPS sequence at the Gly101, Thr102, and Pro106 positions. The results suggest that a yet to be determined mechanism is involved in conferring glyphosate resistance in this Wisconsin giant ragweed phenotype.

ACCASE-INHIBITOR AND GROWTH REGULATOR HERBICIDES APPLIED IN TANK MIXTURES. Ely Anderson*[1], Kasey Schroeder[2], Jeffrey Golus[2], Thomas R. Butts[3], Bruno Canella

Vieira[4], Andre de Oliveira Rodrigues[1], Bonheur Ndayishimiye[5], Greg R Kruger[1]; [1]University of Nebraska, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Arkansas, Lonoke, AR, [4]University of Nebraska, Lincoln, NE, [5]University of Nebraska-Lincoln, Lincoln, NE (10)

Applications of growth regulator herbicides with ACCase-inhibiting herbicides is becoming much more common. It is important to understand how we can control weeds through the use of new developments in technology. While the growth regulator herbicides effectively control broadleaf weeds and ACCase-inhibiting herbicides effectively control monocotyledonous weeds, the tank-mixtures of the two herbicide groups have been reported to cause antagonism in volunteer corn. The goal for this study was to determine whether adding a growth regulator herbicide to an ACCase-inhibiting herbicide would cause antagonistic, synergistic, or additivity in tank mixtures on a range of different grass species. A randomized complete block design with four replications was utilized in a field study at the West Central Research and Extension Center within the University of Nebraska-Lincoln near North Platte, NE. Plots were sprayed using a backpack sprayer to deliver 94 L ha^{-1}. TTI110015 nozzles were operated at 276 kPa on a 50 cm nozzle spacing. Plots consisted of planted rows of oats (*Avena sativa*), rye (*Secale cereale*), and grain sorghum (*Sorghum bicolor*) with a natural population of bristly foxtail (*Setaria verticillata (L.) Beauv.*). Four ACCase inhibitors (clethodim, fluazifop, quizalofop, and sethoxodim) were evaluated at three rates each (low, medium, and high, in respect to the maximum and minimum labeled rates) alone and in combination with either dicamba or 2,4-D. 2,4-D and dicamba were also applied alone. Visual estimations of injury were collected at 7, 14, 21 and 28 days after treatment and data were analyzed using the Colby equation to determine whether the mixtures were antagonistic, synergistic, or additive. No synergistic responses were observed when mixing ACCase-inhibiting herbicides with growth regulator herbicides. Monocotyledonous weeds had either an antagonistic or additive effect depending on the application rate, the growth regulator and the ACCase-inhibiting herbicide rate that was being applied in the plot. More additive responses were obeserved when raising at the highest rate of the ACCase-inhibitor tested when mixed with dicamba. Dicamba and 2,4-D were often antagonistic when paired with flauzofop. Only a few treatments resulted in an additive response. When mixed with dicamba, high rates of flauzifop added to the tank mixture resulted in an additive effect in oats, sorghum and foxtail. Clethodim mixed with 2,4-D resulted in additive and antagonism responses as well. Quizalofop mixed with dicamba showed antagonism in sorghum, foxtail and oats, but showed an additive effect with the highest and second highest rate of quizalofop in rye. 2,4-D with quizalofop had an antagonistic effect across treatments. Sethoxodim mixed with 2,4-D or dicamba was predominantly additive at the medium and high rates of sethoxodim. Dicamba and sethoxodim mixtures had an antagonistic effect across treatments that were exposed to the lowest rate of sethoxodim. In summary, if there are concerns of antagonism in tank mixtures, the use sethoxodim with dicamba or 2,4-D because it was the least likely to have antagonism and. Additionally, using maximum labeled rates of ACCase-inhibiting herbicides reduction antagonism.

GLYPHOSATE, GLUFOSINATE, DICAMBA AND 2,4-D APPLIED IN TANK-MIXTURES ON GLYPHOSATE-RESISTANT, 2,4-D-RESISTANT AND SUSCEPTIBLE WATERHEMP POPULATIONS. Kasey Schroeder*[1], Barbara Vukoja[1], Bruno Canella Vieira[2], Jeffrey Golus[1], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (11)

Common waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) is a major weed invading fields throughout the Midwest. Due to an extended emergence window and resistance evolution to multiple modes of action, waterhemp has become more difficult to manage, even using glyphosate, glufosinate, dicamba, and 2,4-D. A study was conducted at the University of Nebraska Lincoln Pesticide Application Technology Laboratory in North Platte, Nebraska The objective of this study was to investigate the response of glyphosate-resistant, 2,4-D-resistant, and susceptible waterhemp populations to tank-mixtures of glyphosate, glufosinate, dicamba, and 2,4-D. The study was conducted in a Randomized Complete Block design with two runs of four replications in each run. Plants were grown in individual pots to a height of 12-23 cm. Treatments consisted of the four herbicides at 25% of the labeled field rate, in tank-mixtures and alone. All plants were treated using an enclosed track three-nozzle spray chamber with XR11004 nozzles spaced 50.8 cm apart operating at 276 kPa pressure at 3.5 m s^{-1} (12.75 km h^{-1}) to deliver 140 L ha^{-1}. Percent control was evaluated at 7, 14, 21 and 28 days after treatment. At 28 days after treatment, plants were harvested and placed in a drier until a constant mass was reached and dry weight were then recorded. Dry weight reduction relative to the untreated check was then calculated. Data were subjected to ANOVA using a mixed model with run and replication set to random. Means were separated using Tukey HSD at $\alpha = 0.05$. Dicamba + glyphosate was the most effective treatment on the 2,4-D resistant population, followed by 2,4-D + glyphosate and dicamba + glyphosate + glufosinate. The highest visual symptomology was observed on the glyphosate-resistant population with treatments containing 2,4-D + glyphosate + glufosinate, 2,4-D + glyphosate, and 2,4-D + glufosinate. The tank-mixtures of 2,4-D + glyphosate + glufosinate and 2,4-D + glufosinate had the best control on the susceptible population. Utilizing these tank mixtures is a vital tool available to aid in the control of herbicide resistant populations.

EFFICACY OF TRIFLUDIMOXAZIN, A NEW PROTOPORPHYRINOGEN OXIDASE-INHIBITING HERBICIDE, ON PPO-RESISTANT AMARANTHUS BIOTYPES. Nicholas R. Steppig*[1], Samuel D. Willingham[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]BASF, Seymour, IL (12)

Protoporphyrinogen oxidase (PPO)-inhibiting herbicides are commonly used for control tall waterhemp and Palmer amaranth in much of the soybean-producing areas of the US, particularly in areas where these species are resistant to acetolactate synthase (ALS) inhibiting herbicides and glyphosate. However, repeated use of PPO-inhibiting herbicides has resulted in the selection of at least two confirmed target site mutations (ΔG210 and R128) which confer resistance to these herbicides in tall waterhemp and Palmer amaranth. Trifludimoxazin is a new PPO-inhibiting herbicide currently being developed by BASF Corporation, which has been reported to provide postemergence (POST) control of known PPO-inhibitor-resistant Amaranthus biotypes; however little information exists describing the extent of activity on these species, or the effect of different resistance mutations on herbicide efficacy. Therefore, research was designed to compare the efficacy of trifludimoxazin to commercial PPO-inhibiting herbicides on three populations of both tall waterhemp (susceptible, ΔG210, and R128) and Palmer amaranth (susceptible, ΔG210, and an additional target-site mutation). Herbicide applications of trifludimoxazin, saflufenacil, or fomesafen were made at the 4- to 6-leaf stage for plants. In both species, GR_{50} values for the resistant biotypes were higher compared with the susceptible biotype for both fomesafen and saflufenacil applications; however, plant response to trifludimoxazin did not differ when comparing susceptible and resistant biotypes, indicating that trifludimoxazin provides similar efficacy on both susceptible and resistant biotypes. Field validation trials were also conducted over two years near Lafayette, Indiana (<3% native PPO-resistant population via ΔG210 mutation) and near Farmland, Indiana (>30% native PPO-resistant population via ΔG210 mutation). Tall waterhemp control was >90% when trifludimoxazin was applied POST at rates as low as 12.5 g ai ha^{-1} regardless of the PPO-resistance frequency at the two field sites. These results indicate that trifludimoxazin does indeed provide effective POST control of two known mutations for PPO-resistant Amaranthus biotypes. Thus, trifludimoxazin would most likely contribute to the current challenge of improving management of herbicide-resistant biotypes of these two problematic species.

RESPONSE OF ATRAZINE-RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*) TO PRE-APPLIED ATRAZINE. Dakota Came*[1], Junjun Ou[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Corteva Agriscience, Manhattan, KS (13)

Palmer amaranth (*Amaranthus palmeri*) is one of the major weeds in the Midwestern US agriculture as a result of the evolution of resistance to multiple modes of action of herbicides, including atrazine. Many populations of Palmer amaranth throughout Kansas were found resistant to postemergence (POST) applied atrazine. It was recently found that rapid metabolism of atrazine mediated by glutathione-S-transferase (GST) activity contributes to atrazine resistance in Palmer amaranth from KS. However, the responses of atrazine-resistant (AR) Palmer amaranth to preemergence (PRE) application is not known. This research was conducted based on the hypothesis that the PRE applied atrazine can be a viable option to control AR Palmer amaranth. The objectives were: a) assess the response of AR Palmer amaranth to PRE applied atrazine and b) evaluate the control of AR Palmer amaranth when atrazine was applied PRE along with a GST-inhibitor, 4-Chloro-7-nitrobenzofurazan (NBD-Cl). AR and a known atrazine-susceptible (AS) Palmer amaranth populations from KS were used in this study. Dose-response experiments using AR and AS Palmer amaranth were conducted with PRE and POST applications of atrazine (Aatrex 4L) at 560, 1120, 2240 (1x= field recommended dose), 4480, 8960, 17920, or 35840 g ai ha^{-1}. In addition, NBD-Cl was applied as PRE at 270 g ai ha^{-1} followed by several doses of atrazine, only to AR Palmer amaranth. Analysis of plant survival and dry biomass at four weeks after treatment, indicated lack of complete control of AR Palmer amaranth with PRE or POST applied atrazine at doses tested, while AS was controlled at < 1X dose. However, the PRE treatment with the GST-inhibitor, NBD-Cl, increased the control of the AR Palmer amaranth, compared to PRE applied atrazine alone, suggesting that GST enzyme is active in metabolizing atrazine even at the seedling stage. In conclusion, we reject our hypothesis because PRE applied atrazine alone may not be an option to improve the control of AR Palmer amaranth. It is recommended that tank-mixtures of atrazine with other herbicide modes of action (e.g. HPPD-inhibitors or synthetic auxins) may improve control of AR Palmer amaranth.

EFFICACY OF GLUFOSINATE, GLYPHOSATE AND DICAMBA APPLIED IN TANK MIXTURES.
Rodger Farr*[1], Kasey Schroeder[1], Jesaelen Gizotti de Moraes[1], Jeffrey Golus[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (14)

As seed and chemical companies have developed more technologies to increase weed control. With varieties of soybean (*Glycine max* (L.) Merr.) being developed with resistances to glyphosate, glufosinate, and dicamba, it is important to understand how herbicides interact with each other in a tank-mixture. The objective of this study was to determine which type of interaction between glyphosate, glufosinate, and dicamba on control of oat (*Avena sativa* L.), sorghum (*Sorghum bicolor* (L.) Moench ssp bicolor), and velvetleaf (*Abuliton theophrasti* Medik.). The experiment was conducted in two experimental runs (one each across two years) using a Randomized Complete Block Design with four replications. The study was arranged in a 3 x 7 factorial arrangement of treatments with three herbicide rates and seven herbicide solutions.79 The seven tank-solutions were glyphosate alone, glufosinate alone, dicamba alone, glyphosate + glufosinate, glyphosate + dicamba, glufosinate + dicamba, and glypohosate + glufosinate + dicamba.Treatments were applied using a backpack sprayer with a six nozzle boom at XX kPa and a walking speed of XX m sec^{-1}. Visual estimations of weed control were recorded at 7, 14, 21, and 28 days after application. Data were analyzed using SAS Statistical Software and herbicide interactions were analyzed according to the Colby's Method at α=0.05 significance. Most combinations showed an additive interaction. However, the glyphosate + dicamba solution at the two lowest rates were antagonistic on velvetleaf control while the dicamba + glufosinate solution was synergistic for oat control at the lowest rate.

GENE-EDITED ACETOLACTATE SYNTHASE IN YEAST AND RESPONSE TO HERBICIDES.
Michael J. Christoffers*; North Dakota State University, Fargo, ND (15)

Gene editing is the use of biotechnological methods to make specific changes to DNA sequences in living organisms. One of the most common technologies used to perform gene editing is based on CRISPR (clustered regularly interspersed short palindromic repeats), named after its natural configuration within prokaryotic genomes. As a gene-editing tool in eukaryotes, CRISPR involves the use of: 1) an RNA-guided nuclease, which is often Cas9 (CRISPR-associated protein 9); 2) a guide RNA in one or two pieces; and 3) a repair DNA template. The guide RNA directs Cas9 to cut DNA at genomic targets that correspond to the guide RNA's nucleotide sequence. The cell then attempts to repair the cut, often replacing nearby DNA with sequence matching the repair DNA template. To achieve gene editing, a repair DNA template with the desired sequence change(s) is used. The CRISPR-Cas9 gene editing system has potential to be a powerful tool in herbicide-resistance research. Gene editing would allow researchers to make the exact mutations that they wish to study, especially in experimental organisms with established editing protocols. To demonstrate the utility of CRISPR-Cas9 gene editing in herbicide resistance research, we have produced a DNA construct for the expression of Cas9 and a one-piece single guide RNA (sgRNA) targeting the ILV2 acetolactate synthase (ALS) gene of budding yeast (*Saccharomyces cerevisiae*). A repair DNA template specifying replacement of proline with serine at yeast ALS amino acid position 192 (position 197 in most plants), corresponding to a known herbicide-resistance mutation, has also been produced. Yeast co-transformed with the Cas9/sgRNA construct and the repair DNA template is currently being evaluated.

MOLECULAR AND GREENHOUSE VALIDATION OF FIELD-EVOLVED RESISTANCE TO GLYPHOSATE AND PPO-INHIBITORS IN PALMER AMARANTH.
Maxwel Coura Oliveira*[1], Darci Giacomini[2], Patrick Tranel[3], Gustavo De Souza Vieira[4], Nikola Arsenijevic[4], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Illinois, Urbana, IL,

[3]University of Illinois, Urbana, IL, [4]University of Nebraska Lincoln, North Platte, NE (16)

Palmer amaranth (*Amaranthus palmeri*) is one of the most troublesome weed species in row crop production across the US. It has extended emergence window and vigorous growth, which make control with POST-emergence herbicides difficult. Growers have reported that POST herbicide applications in Roundup Ready (RR) soybean systems, which include 5-enolpyruvylshikimate 3-phosphate synthase (EPSPS) inhibitors (e.g. glyphosate) and/or protoporphyrinogen oxidase (PPO) inhibitors, are not providing adequate levels of Palmer amaranth control. Unsatisfactory levels of Palmer amaranth control may not be exclusively due to herbicide resistance. In some cases, poor Palmer amaranth control is a result of improper herbicide application, weed size, and/or adverse environmental conditions. Therefore, the objective of this study was to validate, under greenhouse conditions, the results of molecular confirmation of PPO- and EPSPS-inhibitor resistance in Palmer amaranth populations. Nineteen Palmer amaranth populations from western Nebraska were screened in this study with 20 seedlings herbicide^{-1} run^{-1}, and experimental runs were conducted during the winter, summer, and fall. Palmer amaranth plants were treated when they reached 8-10 cm with EPSPS-(glyphosate) and PPO- (fomesafen) inhibiting herbicides at their field recommended rates. At 21 days after herbicide treatment, plants were rated based on visual estimations of injury and evaluated as dead (susceptible) or alive (resistant). Pearson's correlation coefficient was performed to evaluate how well greenhouse screenings corroborated results from the molecular assay. Results showed a strong correlation between greenhouse and molecular assays (EPSPS gene copy number) for glyphosate resistance. The correlation was higher when Palmer amaranth plants were screened in summer (0.86; $p<0.01$) versus winter (0.43; $p=0.06$). Conversely, greenhouse screening results for fomesafen (PPO resistance) did not directly correlate with results from molecular assays (ΔG210 deletion). The highest correlation for fomesafen (PPO resistance) was during the fall experimental run (0.40; $p=0.09$). Thus, the use of molecular techniques for the detection of glyphosate resistance in Palmer amaranth is robust and accurate, but not necessarily for PPO-inhibiting herbicides. The segregation for herbicide resistance in Palmer amaranth and possible variation in environmental conditions in the greenhouse assays might have influenced our results as correlations also deviate between experimental runs, especially for PPO resistance.

A HIGH-QUALITY WHOLE-GENOME ASSEMBLY OF WATERHEMP (*AMARANTHUS TUBERCULATUS*). Darci Giacomini*[1], Julia M. Kreiner[2], Bridgit Waithaka[3], Felix Bemm[3], Christa Lanz[3], Julia Hildebrandt[3], Julian Regalado[3], Peter Sikkema[4], John R. Stinchcombe[2], Stephen I. Wright[2], Detlef Weigel[3], Patrick Tranel[5]; [1]University of Illinois, Urbana, IL, [2]University of Toronto, Toronto, ON, [3]Max Planck Institute for Developmental Biology, Tuebingen, Germany, [4]University of Guelph, Ridgetown, ON, [5]University of Illinois, Urbana, IL (17)

As transcriptomics- and genomics-based research becomes increasingly affordable and accessible, the production of high-quality reference genomes is essential. A good reference genome not only provides accurate gene models for the genes present in an organism, but also gives the location and ordering of those elements, information that is crucial for work such as linkage mapping and structural regulation studies. Towards this end, high-molecular-weight genomic DNA from a single glyphosate-resistant female waterhemp (*Amaranthus tuberculatus* (Moq.) Sauer) from Illinois was sequenced on a PacBio SMRTcell (Sequel System, v2 chemistry). The resulting long-read data was assembled using Canu (v1.6), and then polished using Arrow (v3.0) and Pilon (v1.22). Heterozygous contigs were reduced using Redundans and then scaffolded to the *A. hypochondriacus* (grain amaranth) genome using REVEAL to give an assembly containing 16 pseudo-chromosomes that represent 99.8% of the waterhemp genome. Following repeat identification/masking of this assembly using RepeatModeler and RepeatMasker, annotations were assigned using BLAST and refined using Exonerate, revealing 30,771 genes total in this species. This assembly and annotation will serve as a valuable resource for the weed science community, providing accurate gene models for known herbicide targets as well as chromosome-level information for any future trait mapping. This assembly also provides insight into the evolutionary history of waterhemp, revealing multiple paleopolyploidy events in this diploid species' past, and helping to refine the placement of this genus within the Amaranthaceae family.

ASSOCIATION BETWEEN METABOLIC RESISTANCES TO ATRAZINE AND MESOTRIONE IN A MULTIPLE-RESISTANT WATERHEMP (AMARANTHUS TUBERCULATUS) POPULATION. Kip E.

Jacobs*[1], Brendan V. Jamison[1], Rong Ma[2], Sarah R. O'Brien[3], Dean E. Riechers[2]; [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Illinois, Urbana, IL, [3]University of Illinois at Urbana-Champaign, Urban, IL (18)

Metabolic resistance to the s-triazines and HPPD-inhibiting herbicides has been reported in waterhemp (*Amaranthus tuberculatus*) populations from the Midwestern US, yet a population has not been confirmed as mesotrione-resistant but sensitive to atrazine. Experiments were designed to test the hypothesis that atrazine- and mesotrione-resistance traits independently segregate in an F2 population derived from a waterhemp population from Mclean County, IL (MCR). A cross was made between a mesotrione-resistant male (MCR-6) and a mesotrione-sensitive female from Washington County, IL (WCS-2) to develop a F1 population, and F1 plants were then intermated to obtain a segregating (pseudo) F2 population due to the dioecious nature of waterhemp. Vegetative clones generated from the MCR-6 and WCS-2 parents displayed the fastest and slowest rates of mesotrione metabolism, respectively, in previous excised leaf studies. Survival of MCR-6 plants following 14.4 kg ha^{-1} of atrazine POST indicated the male parent was homozygous atrazine resistant, and was therefore suitable to test our hypothesis of independent trait segregation. F2 plants were treated with either 105 g ha^{-1} of mesotrione or 2 kg ha^{-1} atrazine postemergence (with adjuvants) and then following a 14-day recovery period several vegetative clones of surviving resistant plants from the first screening were treated with the other herbicide. When mesotrione was applied first resistance frequencies were 8.2% for mesotrione indicating that mesotrione resistance is inherited as a quantitative (multigenic) trait, whereas metabolic atrazine resistance was inherited as a single-gene, incompletely dominant trait (3:1 segregation or 74.9% R plants). These results confirm previous findings reported in the literature. However, mesotrione resistance increased to 15.9% following prior selection for atrazine resistance, and surprisingly 100% of the mesotrione-resistant plants from the first screening were atrazine-resistant (1:0). Our findings indicate an association, or lack of independent segregation, of these two herbicide resistance traits within the experimental population.

ISSUES WITH VOLUNTEER CORN CONTROL IN DICAMBA-TOLERANT SOYBEAN. Jon E Scott*[1], O. Adewale Osipitan[2], Stevan Knezevic[3]; [1]University of Nebraska, Wakefield, NE, [2]University of Nebraska-Lincoln, Linconln, NE, [3]University of Nebraska, Wayne, NE (19)

As herbicide-resistant weeds are present in the Midwest, dicamba use can provide an option for control. Soil residual herbicides are also being recommended, especially those that can be applied postemergence to extend weed control activity. In soybeans, volunteer corn is evident in many fields and a postemengence graminicide is often included as a tank mixture. Loss of efficacy in volunteer corn control has been noticed especially when acetochlor is added to the weed control program of glyphosate + dicamba + clethodim. The focus of this study was to evaluate tank mixtures of several graminicides in dicamba based soybean weed control programs. Initial tests confirmed loss of volunteer corn activity in the four-way tank mixture described above, especially when clethodim (116 g L^{-1}) was used. Reduction in control still occurred with clethodim (240 g L^{-1}) and quizalofop, however slightly less pronounced. Increasing the rate of the graminicide did increase volunteer corn control. Testing with fluazifop indicated only a minimal response in reduction of volunteer corn control when glyphosate, dicamba and acetochlor were in the tank mixture. As application restrictions concerning dicamba increase and soil residual herbicide use increases, volunteer corn control will be impacted. Selection of the proper graminicide and rate will be necessary.

HERBICIDE SELECTION FOR INTERSEEDING COVER CROPS IN CORN. Aaron P. Brooker*[1], Christy Sprague[2], Karen Renner[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (20)

Seeding of most cover crop species following corn grain harvest in Michigan is not possible due to season constraints. Interseeding cover crops at the V3 and V6 growth stages in corn allows establishment of grasses, clovers, vetches, cover crops in the Brassicaceae family, and cover crop mixtures. However, weed control in corn becomes problematic when interseeding cover crops in corn in June because the cover crops must be tolerant of the herbicide(s) applied in corn to manage herbicide-resistant weeds and protect corn grain yield. Therefore, the objective of this research was to determine tolerance of various cover crop species to soil-applied and postemergence corn herbicides. From 2016 to 2018, field trials were conducted in Michigan to test the tolerance of annual ryegrass, cereal rye, crimson clover, red clover, Tillage Radish®, and dwarf Essex rape to thirteen soil-applied and fourteen postemergence herbicides.

Cover crops were interseeded into corn at the V3 and V6 growth stages. Greenhouse experiments were also conducted where soil-applied herbicides were applied at 1x, 0.5x, and 0.25x standard application rates, postemergence herbicides were applied at 1x and 0.5x standard application rates, and annual ryegrass, crimson clover, and Tillage Radish® were seeded following herbicide applications. At both interseeding timings, annual ryegrass was tolerant of soil-applied atrazine, isoxaflutole, bicyclopyrone, mesotrione, saflufenacil, and clopyralid and postemergence atrazine, bromoxynil, fluthiacet, mesotrione, and mesotrione + atrazine. Tillage Radish® was tolerant of soil-applied atrazine, s-metolachlor, dimethenamid-P, acetochlor, saflufenacil, bicyclopyrone and clopyralid, and postemergence bromoxynil, and topramezone at both the V3 and V6 timings. Tillage Radish® was tolerant of soil-applied mesotrione, isoxaflutole, and pyroxasulfone and postemergence topramezone and acetochlor when seeded at V6. Dwarf Essex rape and crimson clover did not emerge consistently in any site year but were both tolerant of saflufenacil. Cereal rye had poor emergence in every site year and should not be interseeded at V3 and V6 in corn in Michigan. There are many soil-applied and postemergence herbicide options available when interseeding annual ryegrass or Tillage Radish® alone, but options are very limited when seeding cover crop mixtures (grass + brassica + clover).

INFLUENCE OF COVER CROP SELECTION ON WEED SUPPRESSION AND SUBSEQUENT CORN YIELD IN SEMI-ARID RAINFED CROPPING SYSTEMS OF WESTERN NEBRASKA. Italo Kaye Pinho de Faria*[1], Alexandre Tonon Rosa[2], Liberty E. Butts[3], Cody F. Creech[4], Roger Elmore[2], Daran Rudnick[1], Rodrigo Werle[5]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Scottsbluff, NE, [5]University of Wisconsin-Madison, Madison, WI (21)

Cover crops (CC) are becoming popular across Nebraska (NE). CC have the potential to reduce soil erosion and compaction, increase soil health, and suppress weeds. Producers in semi-arid of western NE are questioning whether and which CC species would fit their cropping systems without affecting subsequent crop yields. The objective of this study was to examine biomass production of CC species and how they influence weed suppression and subsequent corn yield. The trial was conducted in a randomized complete block design with four replications at North Platte and Grant, western NE, during the 2016-2017 and 2017-2018 growing seasons. Treatments consisted of: no CC, spring triticale, cereal rye, spring oats, purple-top turnip, Siberian kale, balansa clover and hairy vetch. CC were drilled in the summer following winter wheat harvest. CC biomass was collected during fall (2016 and 2017) and spring (2017 and 2018). Glyphosate was applied in plots two weeks prior corn planting. Corn was planted mid-May (2017) and late-May (2018). Weeds density and biomass were evaluated when corn reached the V6 growth stage. Corn yield was determined at crop maturity. Spring oats produced the highest amount of biomass in the fall across both years and sites. Cereal rye, spring triticale and hairy vetch (winter-hardy species) produced biomass in the spring. Across sites and seasons, cereal rye produced the highest amount of biomass in the spring, and also provided the highest suppression (weeds population and biomass) of weeds during the corn-growing season (73-98% weed biomass reduction compared to no CC plots). In 2016/2017, no CC plots had the highest corn grain yield at both areas, followed by spring oats at North Platte and spring triticale at Grant. According to our results, CC have the potential to suppress summer annual weeds, whereas the CC biomass accumulation in the spring had a greater impact when compared to fall biomass production. However, cover crops must be timely terminated under semi-arid environments to avoid corn yield reduction.

IMPACT OF WHEAT STUBBLE MANAGEMENT AND COVER CROP SELECTION ON WEED DEMOGRAPHICS AND CORN PRODUCTIVITY IN SEMI-ARID CROPPING SYSTEMS OF WESTERN NEBRASKA. Alexandre Tonon Rosa*[1], Italo Kaye Pinho de Faria[2], Roger Elmore[1], Chuck Burr[2], Strahinja Stepanovic[3], Daran Rudnick[2], Cody F. Creech[4], Rodrigo Werle[5]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Grant, NE, [4]University of Nebraska-Lincoln, Scottsbluff, NE, [5]University of Wisconsin-Madison, Madison, WI (22)

Producers are questioning whether the incorporation of cover crops (CC) in semi-arid areas would aid weed management and impact grain yield of subsequent crops. The objective of this study was to evaluate the impact of wheat stubble management height combined with CC species selection on CC biomass production, soil water, weed demographics and subsequent corn productivity. The study was established in 2017 at North Platte and Sidney, western NE. Treatments consisted of two wheat stubble heights (short and tall) and three CC mixes: i) winter-sensitive mixture (WS) killed in the winter, ii) winter-hardy mixture (WH) terminated two wk before corn planting with glyphosate, and iii) no CC (NCC). The experiment was conducted in a randomized complete block design with four replications. Cover crop biomass was collected during fall 2017 and spring 2018. Corn was planted late-May 2018. Soil water readings were recorded during CC and corn growing seasons. Weed density and biomass were recorded when corn reached the V6 growth stage. Cover crop biomass accumulation in the fall was 120% higher in North Platte than Sidney, mainly due the different rainfall amounts received at each location. At Sidney, lower soil water content was detected in WS and WH treatments at deeper layers. Tall wheat stubble and WH species reduced weed density by 50% compared to NCC treatment at Sidney. No differences between treatments were found in North Platte regarding weed density and biomass. Between sites, WH species reduced corn grain yield by 1533 and 1022 kg ha^{-1} compared to NCC and WS treatments. Though CC did not have a major impact on soil water content, they reduced corn grain yield, likely due to induced nitrogen immobilization. Proper management should be adopted when incorporating CC in cropping systems of semi-arid regions.

IMPACT OF ORGANIC HERBICIDES IN CORN. Betzy Valdez*, Kerry M. Clark, Reid Smeda; University of Missouri, Columbia, MO (24)

Repeated tillage is the primary in-season method for weed control in organic corn production. However, reduced soil health and increased erosion is common with tillage. The objective of this research was to determine if post-directed organic herbicides could effectively control weeds in organic corn (*Zea mays*). In central Missouri, corn was planted in three m wide plots with 76-cm rows in both 2017 and 2018; feather meal was used as a nitrogen source. As weeds reached 8 cm in height, repeated application of plant oils (manuka, clove + cinnamon, or d-limonene) and acids (acetic or caprylic + capric) were made at 374 L ha^{-1} between crop rows using a shielded sprayer. A total of five to six applications were made between crop emergence and canopy closure. Following each application, symptomology on sensitive plants developed within 24 to 48 hr. Prior to grain harvest in 2017 and 2018, weed biomass was reduced by 66 to 97% using caprylic + capric acid, compared to the untreated control. In 2017 and 2018, caprylic + capric acid resulted in an average of 53 and 96% visual weed control for grasses and broadleaves, respectively. Similarly, D-limonene resulted in 40% (grasses) and 93% (broadleaves) visual control in both years. Hot and dry weather conditions in 2018 contributed to more effective weed control than 2017 (cooler and wet). In the two year period, caprylic + capric acid resulted in 20 to 67% higher yields in 2017 and 2018 respectively, versus the untreated control. Post-directed, organic herbicides may provide a viable alternative to continued tillage for weed management in corn.

INTERACTIVE IMPACT OF WEED REMOVAL TIMING AND PRE HERBICIDES ON GROWTH AND YIELD OF CORN. Ayse Nur Ulusoy*[1], O. Adewale Osipitan[2], Jon E Scott[3], Stevan Knezevic[4]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Nebraska-Lincoln, Linconln, NE, [3]University of Nebraska, Wakefield, NE, [4]University of Nebraska, Wayne, NE (25)

A weed control program that utilizes PRE herbicides and ensure a timely postemergence weed removal could prevent growth and yield reduction in corn. A field study was conducted at the experimental farm of Haskell Agricultural Laboratory, Concord, Nebraska in 2017 and 2018, to evaluate how timing of weed removal and PRE herbicides application could influence growth and yield of glyphosate-tolerant corn. The studies were arranged in a split-plot design with three herbicide regimes (No PRE and PRE application of two herbicides) as main plots and seven weed removal times (V3, V6, V9, V12, V15 corn growth stages as well as weed free and weedy season long) as sub-plots in four replications. The two PRE herbicides were atrazine, and saflufenacil plus dimethenamid plus pyroxasulfone in 2017 and 2018. Corn growth parameters such as plant height, leaf area per plant, leaf area index and corn plant dry weight were collected at corn tasseling stage (VT growth stage). Corn yield and yield components such as number of ears $plant^{-1}$, number of kernels ear^{-1}, 100 kernel weight and grain yield were collected at physiological maturity. In 2017, 5% reduction in corn dry weight occurred when weed removal was delayed until 91 GDD after emergence (V2 growth stage) without PRE herbicide, while the PRE application of atrazine or saflufenacil plus dimethenamid plus pyroxasulfone allowed corn to grow until 162 GDD (V5 growth stage) and 302 GDD (V7 growth stage) respectively, to reach the same 5% threshold. In 2018 no difference was observed in 5% reduction in corn biomass, corn yield, and number of kernels ear^{-1} between no-PRE and atrazine treatments. In general, there was an interaction between PRE herbicide and weed removal timing, as the required time for postemergence weed removal depends on the PRE herbicide regimes.

EFFECTS OF SHADING ON WEED AND COVER CROP GROWTH PARAMETERS. Adam L. Constine*[1], Karen Renner[2], Aaron P. Brooker[1]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (26)

Interseeding cover crops into corn during the month of June in the upper Midwest gives farmers more options for cover crop species selection and additional times to seed that fit farming operations. Farmers know weeds growing in a corn crop reduce grain yield and question if cover crops growing in corn will do the same. The objective of this research was to compare cover crop and weed growth under varying levels of photosynthetically active radiation (PAR). Cereal rye, annual ryegrass, Tillage Radish®, crimson clover, common lambsquarters and giant foxtail were seeded in pots in the greenhouse and placed under shade treatments one wk after emergence. Shade treatments were achieved using 60% and 30% shade cloth (214 and 566 PAR, respectively) or no shade cloth (818 PAR). Aboveground biomass was harvested one, two and three wks after shade treatment placement, and relative growth rates calculated from dry weights. Relative chlorophyll content and photosystem II efficiencies were measured at the wk three final harvest using a MultispeQ. Relative chlorophyll content decreased as shading increased. The efficiency of photosystem II was greater in common lambsquarters compared with the two cool season grass cover crop species. The 60% shade treatment reduced aboveground biomass and relative growth rate for all plant species. Weeds had higher relative growth rates compared with the cover crop species evaluated, suggesting that weeds growing in a shaded corn canopy would be more competitive than cool season cover crop species.

POSTEMERGENCE CONTROL OF VELVETLEAF IN POPCORN. Ethann R. Barnes*[1], Suat Irmak[1], Stevan Knezevic[2], Nevin C. Lawrence[3], Oscar Rodriguez[4], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Wayne, NE, [3]University of Nebraska, Scottsbluff, NE, [4]Conagra Brands, Inc, Brookston, IN (27)

Velvetleaf can emerge throughout the summer and is an economically important weed species in popcorn production fields in Nebraska. Many pre-emergence (PRE) herbicides commonly applied in popcorn (*Zea mays* var. *everta*) production fields such as atrazine/S-metolachlor have limited residual activity or can only partially control velvetleaf. Postemergence (POST) herbicides are limited in popcorn compared to field corn, necessitating the evaluation of POST herbicides for the control of velvetleaf. A field experiment was conducted at the University of Nebraska—Lincoln, South Central Agricultural Laboratory near Clay Center, NE in 2018. The objective was to evaluate the efficacy of POST herbicides for controlling 15- or 30-cm tall velvetleaf in popcorn. A factorial treatment structure which included two application timings and 11 POST herbicides was laid out in a randomized complete block design with four replications. Carfentrazone, fluthiecet, dicamba, dicamba/diflufenzophyr, dicamba/tembotrione, mesotrione/fluthiacet, and nicosulfurone/mesotrione resulted in ≥ 96% velvetleaf control, ≤ 12 plants m^{-2} density, ≥ 98% biomass reduction, and yields ranging from 4,886 to 5,597 kg ha^{-1} at 28 days after treatment (DAT) when applied to 15-cm tall velvetleaf. The previously mentioned herbicides in addition to halosulfuron and dicamba/halosulfuron resulted in ≥ 90% control, ≤18 plants m^{-2} density, ≥ 91% biomass reduction, and yields ranging from 4,190 to 5,480 kg ha^{-1} at 28 DAT when applied to 30-cm tall velvetleaf. Topramezone resulted in poor control of velvetleaf regardless of velvetleaf height. Popcorn lodging in the range from 25 to 40% was observed from tembotrione, halosulfuron, nicosulfuron/mesotrione, and dicamba/halosulfuron. The results of this research indicated that effective POST herbicide options are available for control of 15- to 30-cm tall velvetleaf in popcorn production.

A SHORT COURSE ON HERBICIDE MODES OF ACTION AND HERBICIDE RESISTANCE. Peter H. Sikkema*[1], Patrick Tranel[2], Thomas Mueller[3]; [1]University of Guelph, Ridgetown, ON, [2]University of Illinois, Urbana, IL, [3]University of Tennessee, Knoxville, TN (28)

Weed control has faced many challenges over the years, and herbicides have greatly aided farmers and others in their efforts to reduce the negative effects of weeds. In broad acre crops, glyphosate-resistant (GR) varieties have been commonly used in overly simple weed control regimes in soybeans, cotton, corn and other crops. The widespread occurrence of GR weeds has reduced the utility of GR crops, and has resulted in a renewed interest in alternate herbicide chemistries. This poster details an educational short course to be held in 2019 that covers the various modes of action and also herbicide resistance to those various chemicals. Practical aspects of herbicide use and optimization of weed control strategies are important topics extensively covered in this course.

CORN EAR SIZE AS INFLUENCED BY PROXIMITY TO WINTER ANNUAL WEEDS AT EMERGENCE AND SIDE-DRESS NITROGEN RATE. Brent Heaton*[1], Mark L. Bernards[2]; [1]Western Illinois University, Industry, IL, [2]Western Illinois University, Macomb, IL (29)

Winter annual weeds that are not controlled at least two wks before planting corn (*Zea mays*) may cause yield losses of up to 17%. The presence of weeds shortly after corn emergence has been shown to increase the variability of growth properties and yield among corn plants adjacent to the weeds. Our objectives were to 1) compare ear size and components as they are affected by the presence or absence of a winter annual weed adjacent to an emerging corn plant, and 2) determine if increasing nitrogen rate may minimize negative effects caused by the presence of the winter annual weed at the time of corn emergence. Experiments were conducted in 2017 and 2018. Corn was planted in 76-cm rows. Nitrogen (urea ammonium nitrate, [32-0-0]) was side-dressed at 0, 84, 140, 196, and 252 kg N ha^{-1}. Ten plants $plot^{-1}$ that emerged adjacent to a weed were marked, and 10 plants pot^{-1} that were not adjacent to a weed were marked. After corn reached maturity, ears were harvest from the marked plants and from one plant on each side of the marked plants. Ears were weighed and kernel counts were estimated by counting the number of rows and kernels row^{-1}. Yield of each plot was measured using a plot combine. In 2017, corn grain yield increased to 250 kg N ha^{-1}. Ear weights and kernel counts from corn plants that were adjacent to a winter annual weed at emergence were approximately 20% less than for weed free plants at all N rates. Increasing nitrogen rates increased yield of plants that emerged adjacent to weeds, but did not compensate for yield potential lost to the presence (competition) of weeds at emergence.

AMARANTHUS GERMINATION IN ROAD DITCHES: POTENTIAL IMPLICATIONS FOR THE SPREAD OF PALMER AMARANTH. Cole Sigler*[1], Lauren Villafuerte[1], Manoj Rai[1], Clint Meyer[1], John Pauley[2]; [1]Simpson College, Indianola, IA, [2]Simpson college, Indianola, IA (30)

The genus Amaranthus includes several agriculturally important weed species. Although in-field management of these weeds has received a lot of attention, relatively less attention has been paid to potential establishment in ditches. We tested whether *Amaranthus hypocondriachus* would germinate in established stands of smooth brome (*Bromus inermis*). We also looked at the role mowing of ditches might play by comparing Amaranthus germination in clipped and non-clipped brome. We found that Amaranthus germination was higher in control pots in which brome had been removed (P=0.047). Furthermore, clipping brome did not impact germination (P=0.15). However, we did find germination in established brome. Any Amaranthus plants germinating in ditches would serve as a seed source. Therefore, management should incorporate those habitats. If a serious agricultural pest such as Palmer amaranth (*Amaranthus palmeri*) shows similar germination abilities, we argue for increased ditch surveillance by producers as well as increased resources provided to weed commissioners to help stop the spread of this noxious weed. Future work should include testing of Palmer amaranth germination in ditches.

WEED SPECIES DIVERSITY IN RAILROAD RIGHT-OF-WAYS. Andrew W. Osburn*, Mark Loux, Emilie Regnier, Kent Harrison; The Ohio State University, Columbus, OH (31)

Vegetation control along railroad right-of-ways is a ubiquitous practice within the US. Many methods are employed to achieve control, but herbicide application is the most efficient and economical. Due to varied herbicide treatment programs, strong selective pressures may be exerted upon weed species present in railway environments, leading to selection for tolerant species and resistant biotypes. There has been little previous research on the impact of intensive herbicide use on railway species diversity, seedbanks, and peripheral environments. The goal of this research was to gain a better understanding of seedbanks near railroad crossing right-of-ways, with the following specific objectives: 1) determine the difference in plant species diversity between areas treated most heavily with herbicides (crossing control) and those receiving less intensive herbicide treatment (roadbed control); 2) determine the difference in plant species diversity between urban and rural railroad crossings; and 3) characterize the plant populations present for their response to glyphosate. At each crossing, soil was sampled to a depth of 5cm in the crossing zone (high intensity herbicide treatment) and roadbed zone (moderate intensity herbicide treatment). Seedbanks were characterized by germination assays in the greenhouse. Preliminary results for the seedbank show that roadbed control sites did not differ in diversity from crossing control sites, based on Shannon's Index (H) = 1.55 (0.13) and H = 1.36

(0.15), respectively. Urban sites had greater diversity H = 1.65 (0.12), than rural sites, H = 1.26 (0.13). Application of glyphosate at 1.5 kg ae ha^{-1} controlled most species that grew in soil samples, with some exceptions, notably horseweed and waterhemp. Seed was collected from the surviving plants, and these populations will be screened again for response to several herbicide sites of action to characterize herbicide resistance.

VASTLAN - A NOVEL LOW VOLATILE FORMULATION OF TRICLOPYR. David G. Ouse*[1], James Gifford[2], Byron Sleugh[2], Stephen Strachan[2], Dave Barenkow[2]; [1]Corteva agriscience, Indianapolis, IN, [2]Corteva, Indianapolis, IN (32)

Synthetic auxin herbicides are a vital component in managing vegetation such as weeds and brush in non-crop land such as pastures, roadsides, utility right-of-ways, railroad, wildlife habitat, natural areas, etc. In recent years there has been a lot of news from the cropping sector around off-target movement of herbicides and especially synthetic auxins. Managing the risk of off-target movement of herbicides from applications in non-crop sites is also imperative for responsible use. Corteva Agriscience™ has a strong commitment to product stewardship and providing technology that reduces risks of off-target movement from our herbicides, including triclopyr. A triclopyr choline formulation was prepared and tested in whole plant humidome trials in a growth chamber to determine if it offered reduced volatility compared to triclopyr trimethylamine (TEA) and butoxyethylester (BEE). Treatments of triclopyr were applied on ryegrass and allowed to dry for 15 min prior to transfer to the humidome. Grapes and tomatoes, highly sensitive to triclopyr, were exposed to vapor from triclopyr TEA, BEE or choline for 24 hours in the humidome held at a constant temperature of 40 C. Plants were removed from the humidome and transferred to a greenhouse to monitor their growth for 2 wks. Triclopyr choline provided much reduced plant injury and greater dry weights compared to plants exposed to triclopyr TEA or BEE.

PGR OPTIONS FOR ROADSIDE TALL FESCUE MANAGEMENT (2017-2018). Joe Omielan*, Michael Barrett; University of Kentucky, Lexington, KY (33)

Tall fescue is a widely adapted species and is a common roadside and other unimproved turf cool season grass. Frequent mowing is the most common management regime for departments of transportation. Plant growth regulators (PGRs) are potential tools to reduce turf growth and aid in keeping our roadways safe for travelers. This trial was established and repeated to evaluate some PGR options for roadside management. A trial was established in 2017 and 2018 at Spindletop Research Farm in Lexington, KY arranged as a complete block design with 21 PGR treatments and three replications. Plots were 2 m by 6 m with running unsprayed checks between each of the plots. The treatments were five PGRs applied before the first mowing and one to two wks after each of the three mowing timings plus control. Products tested were Embark 2S (mefluidide), Plateau (imazapic), Opensight (aminopyralid + metsulfuron methyl), Anuew (prohexadione calcium), and Perspective (aminocyclopyrachlor + clorsulfuron). Applications were at 234 L ha^{-1} and included a non-ionic surfactant at 0.25% v $v\text{-}^{1}$. Application dates were 4/26, 6/1, 8/8, and 10/6 for the 2017 trial. Application dates were 4/29, 6/14, 8/24, and 10/19 for the 2018 trial. Tall fescue color was assessed by comparison to the running check strips. The color rating ranges from 0 (dead) to 9 (full green). The color of the check strips was set at 8. Seedhead suppression was assessed before the first mowing. Canopy heights were measured. Data were analyzed using ARM software and treatment means were compared using Fisher's LSD at p = 0.05. The effects of the PGR treatments were variable, however in general, many of the treatments reduced grass height along with turf color but color recovered afterwards.

GENERATIONS: UNDERSTANDING WEED-HERBIVORE INTERACTIONS USING PYTHON. Mary Marek-Spartz*[1], Kyle Marek-Spartz[2], George Heimpel[1], Roger Becker[3]; [1]University of Minnesota, St. Paul, MN, [2]Consultant, St. Paul, MN, [3]University of Minnesota, St Paul, MN (34)

Ecologists use coupled consumer-resource equations to model population interactions between biological control agents and their target hosts. In weed biological control, these interactions are often strongly affected by complex life-history traits of invasive plants and associated herbivorous agents. Tools for modeling these multi-dimensional interactions can help to predict the establishment and impact of imported biological control agents on target weed populations. Generations is an open-source Python package containing customizable modules for understanding population dynamics of biological control agents and their target hosts. Generations employs functional programming to provide a set of equations and parameters to model the response of a seedbank-dependent plant to an herbivorous biological control agent. The package includes a baseline model for a coupled plant-herbivore interaction described by Buckley et al. (2005; J. Appl. Ecol. 42:70-79), along with a modified version of that model incorporating stage-structured interactions with a biennial plant. We present an example of Generations applied to interactions between the invasive biennial weed garlic mustard (*Alliaria petiolata*) and a univoltine biological control weevil *Ceutorhynchus scrobicollis*.

HOST SPECIFICITY OF *HADROPLONTUS LITURA* ON NATIVE *CIRSIUM* SPECIES.
Elizabeth Katovich*[1], Roger Becker[2], Mary Marek-Spartz[1]; [1]University of Minnesota, St. Paul, MN, [2]University of Minnesota, St Paul, MN (35)

The invasive plant Canada thistle (*Cirsium arvense*) is native to Eurasia and is a serious threat to natural ecosystems. In Minnesota, Canada thistle is listed as a Prohibited Noxious Weed, mandating management efforts be taken to prevent spread of seed and vegetative propagules. Biological control of Canada thistle could reduce herbicide use in Minnesota's natural areas. In 1998, the stem-mining weevil (*Hadroplontus litura*) was introduced into a limited area in Minnesota. Anecdotally, *H. litura* is thought to be host specific and land managers are interested in releasing *H. litura*. Before recommending release on a broader scale throughout Minnesota, we need to determine whether this stem-mining weevil can attack Minnesota's native Cirsium spp. For this study, we conducted host range oviposition and development tests for *H. litura* on five Cirsium species native to Minnesota; tall thistle (*Cirsium altissimum*), field thistle (*Cirsium discolor*), Flodman's thistle (*Cirsium flodmanii*), swamp thistle (*Cirsium muticum*), and Hill's thistle (*Cirsium pumilum* var. *Hillii*), a listed species of concern in Minnesota and two native Cirsium species in adjacent states; Pitcher's thistle (*Cirsium pitcheri*), a federally listed Threatened Species, and wavyleaf thistle (*Cirsium undulatum*). Results of our study indicate that *H. litura* was able to complete development on swamp, Flodman's, field, and tall thistle in no-choice oviposition and development tests. These Cirsium spp. are within the fundamental host range of *H. litura*. In no-choice development tests, female *H. litura* laid eggs on both Hill's and Pitcher's thistle, and larval tunneling was documented in Pitcher's thistle. Further field studies could address whether these native Cirsium spp. are also within the ecological host range of *H. litura*.

WSSA ADVOCATES FOR WEED CONTROLS THAT PROTECT SOYBEAN EXPORT VALUE.
Carroll M. Moseley*[1], Lee Van Wychen[2], Heather Curlett[3], Jill Schroeder[4], Patsy D. Laird[5], Shawn P. Conley[6]; [1]Syngenta Crop Protection, Greensboro, NC, [2]WSSA, Alexandria, VA, [3]APHIS-USDA, Washington, DC, [4]USDA Office of Pest Management Policy, Washington, DC, [5]Syngenta Crop Protection, LLC, Greensboro, NC, [6]University of Wisconsin-Madison, Madison, WI (37)

Weeds and weed seeds are a serious phytosanitary concern. Most countries, including the United States, take action when weed seeds are detected in arriving shipments. The importing country may reject, re-export, or destroy the shipment. In the worst case, the country may suspend imports or close the market altogether. Soybeans are one of the United States' top exports. Increases in herbicide-resistant weeds may be contributing to more weed seeds in harvested beans. There are a number of best practices—many of which are already in use here in the United States—that can be applied on farm and by grain handlers to help reduce weed seeds in U.S. soybeans.

CROP SAFETY OF PREPLANT APPLICATIONS OF HALAUXIFEN-METHYL ON SOYBEAN.
Marcelo Zimmer*[1], Bryan G. Young[1], Bill Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, W Lafayette, IN (38)

Synthetic auxin herbicides are often applied as burndown treatments for horseweed control prior to soybean planting. Synthetic auxins such as 2,4-D and dicamba must be applied at least 14 days before planting of sensitive varieties due to potential soybean phytotoxicity. Halauxifen-methyl is a new synthetic auxin herbicide for horseweed control in preplant burndown applications in soybean. Field experiments were conducted to evaluate soybean phytotoxicity in response to applications of halauxifen-methyl (5 g ae ha^{-1}) at five different preplant intervals [0, 1, 2, 3, and 4 wks before planting (WBP)]. In 2015, soybean phytotoxicity did not occur for any of the preplant intervals at any of the sites. In 2016, phytotoxicity was observed at 14 days after planting (DAP) for treatments applied at planting, one WBP, and two WBP at different sites, ranging from 0 to 15%. Soybean phytotoxicity was observed in the unifoliate leaves only at 14 DAP. The first trifoliate did not show any symptoms at 21 DAP, thus crop phytotoxicity was deemed negligible at 21 DAP for all sites. Preplant intervals for halauxifen-methyl did not affect soybean stand counts or grain yield at any site-year. Therefore, field results indicate that halauxifen-methyl can cause soybean phytotoxicity in preplant applications; however, plants can quickly overcome phytotoxicity. Growth chamber bioassays were conducted in 2018 to evaluate how environmental conditions such as temperature and soil moisture can influence soybean phytotoxicity levels to halauxifen-methyl soil residual. A two-way interaction was observed between herbicide rate and temperature, where plant length reduction at 30 C was greater than at 20 and 15 C as herbicide rate increased. These results contradict the currently held paradigm in which lower temperatures generally increase crop phytotoxicity to herbicide soil residual.

WINTER ANNUAL WEED CONTROL IN SOYBEAN WITH HAULAXIFEN-METHYL. Anthony F. Dobbels*, Mark Loux; The Ohio State University, Columbus, OH (39)

Horseweed continues to be one of the most troublesome weeds in Ohio, due to essentially year-long emergence and resistance to site 2 and 9 herbicides. The combination of glyphosate and 2,4-D has been a foundation for spring burndown herbicide programs in no-tillage soybeans, but control of emerged glyphosate resistant (GR) horseweed with this has become variable. This is because the 2,4-D has insufficient activity on overwintered or well-established horseweed plants, without the addition of other herbicides. Field studies were conducted to determine whether the addition of halauxifen-methyl, a novel auxin-type herbicide for use prior to soybean planting, would provide effective horseweed control. The studies were conducted in 2017 and 2018 at the OARDC Western Agriculture Research Station in South Charleston, Ohio. Herbicides were applied on April 17, 2017 when horseweed were 8-cm tall, and on May 17, 2018, when horseweed were 13-cm tall. In 2017, the combination of glyphosate, halauxifen-methyl, and 2,4-D controlled at least 90% of horseweed 28 days after treatment (DAT), while the combination of glyphosate and 2,4-D resulted in 68% control. In 2018, glyphosate, halauxifen-methyl, and 2,4-D controlled 74% of GR horseweed 28 DAT, while glyphosate and 2,4-D controlled 53%. In both years, combinations of halauxifen-methyl with glyphosate, glyphosate and 2,4-D, or glyphosate, 2,4-D and residual herbicides resulted in complete control of purple deadnettle, bushy wallflower, and field speedwell. These combinations also provided greater than 95% control of giant ragweed 14 DAT in 2018, but control decreased to less than 60% at 28 DAT due to new emergence. The addition of halauxifen-methyl to glyphosate and 2,4-D can improve horseweed control, but the degree of improvement may depend upon factors that generally affect control, such as plant size, age and environmental conditions.

THE SPATIAL AND TEMPORAL DISTRIBUTION OF HORSEWEED IN OHIO SOYBEAN FIELDS FROM 2013 TO 2017. Alyssa Lamb*, Mark Loux, Bruce A. Ackley, Anthony F. Dobbels; The Ohio State University, Columbus, OH (40)

Surveys were conducted annually from 2013 through 2017 in 49 to 52 Ohio counties to evaluate the frequency, distribution, and infestation levels of horseweed (*Conyza canadensis*), giant ragweed (*Ambrosia trifida*), common ragweed (*Ambrosia artemisiifolia*), and three Amaranthus or 'pigweed' species at the end of the season in soybean fields. Horseweed was the most frequently encountered species in all years, followed by giant ragweed, pigweeds, and common ragweed, respectively. Horseweed also had the greatest number of infestations (highest density) each year, followed by giant ragweed, common ragweed, and pigweed species, respectively. Spatial cores of interest, or counties identified as having significant levels of horseweed infestations or lack thereof, relative to surrounding counties, were identified in 2013, 2014, 2015 and 2016, but not 2017. The lowest total frequency of horseweed occurred in 2017, which coincided with the second highest frequency of infestations among years. There was no distinct distribution or pattern of horseweed movement within the state from year to year, but there did seem to be an increase in counties with one to three infested fields over time compared to the early years of the survey where many counties had one or no infested fields. These results suggest that horseweed persists as a common and troublesome threat to Ohio soybean producers, and that growers should still consider making horseweed management a priority when developing weed management programs.

ALTERNATIVE SITES OF ACTION FOR RESIDUAL CONTROL OF MULTIPLE-RESISTANT HORSEWEED IN SOYBEANS. Bryan Reeb*, Mark Loux; The Ohio State University, Columbus, OH (41)

Most populations of horseweed in Ohio have become resistant to glyphosate and acetolactate synthase-inhibiting (ALS) herbicides are common components for management of horseweed. One consequence of this resistance is a lack of residual control from chlorimuron and cloransulam, which are components of many preemergence premixure products. Herbicides with residual activity on ALS-resistant horseweed include flumioxazin, metribuzin, and sulfentrazone, and also higher rates of saflufenacil. Due to a relatively short and variable period of residual activity on horseweed, combinations of these herbicides provide the most consistently effective control. Due to new soybean herbicide resistance traits and some renewed emphasis on older active ingredients, possible new options for residual control include isoxaflutole, mesotrione, and KFD-308-01 (a site 13 herbicide widely used in rice). Field studies were conducted in the summer of 2018 to determine the effectiveness of these herbicides for residual control of horseweed, applied alone and in combination with other soybean herbicides. The first study was conducted in HPPD-resistant soybeans and focused on preplant treatments of isoxaflutole and mesotrione. Residual herbicides were applied 14 days prior to soybean planting, with glyphosate plus 2,4-D ester, and followed with a postemergence application of glyphosate approximately four wks after planting. Control in isoxaflutole-containing treatments, at rates of 70 and 105 g ai ha^{-1}, exceeded 92% from planting through harvest. Mesotrione applied at 105 and 180 g ai ha^{-1} controlled 63 to 80%of horseweed across ratings. Control increased to 100% when 180 g ai ha^{-1} of mesotrione was applied with metribuzin, flumioxazin, or sulfentrazone. The second study was conducted in dicamba-resistant soybeans, focusing on preplant applications of KFD-308-01 or KFD-308-01 plus metribuzin, and combinations of these with flumioxazin, sulfentrazone, saflufenacil, pendimethalin, or metolachlor. Herbicides were applied seven days prior to soybean planting, with glyphosate plus dicamba. Combinations of KFD-308-01 with other residual herbicides controlled 76 to 86% of horseweed in early June, but this increased to 91 to 100% when metribuzin was also included. Results of these studies show that isoxaflutole, mesotrione, and KFD-308-01 have substantial residual activity on horseweed. The latter two herbicides would have to be combined with other effective herbicides to provide adequate control, unless followed with a postemergence treatment that controlled horseweed.

CONTROL OF GLYPHOSATE-RESISTANT PALMER AMARANTH IN ISOXAFULTOLE/GLUFOSINATE-RESISTANT SOYBEAN IN NEBRASKA. Jasmine Mausbach*[1], Parminder Chahal[2], Kevin Watteyne[3], Amit Jhala[2]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Bayer CropScience, Lincoln, NE (42)

Palmer amaranth is the most problematic and troublesome weed in the agronomic cropping system in the US. A Palmer amaranth biotype resistant to glyphosate was reported in a grower's field under corn-soybean rotation at Carleton, NE. A field study was conducted at that site to evaluate isoxaflutole and glufosinate based herbicide programs for the management of glyphosate-resistant Palmer amaranth in isoxaflutole/glufosinate-resistant soybean. Isoxaflutole is a soil residual PRE herbicide labeled for control of broadleaf weeds including Palmer amaranth in corn. A soybean variety resistant to isoxaflutole and glufosinate has been developed to provide additional herbicide sites of action for the control of herbicide-resistant weeds in soybean. The treatments in the experiment were laid out in a randomized complete block arrangement with four replications including a non-treated control. At 14 days after PRE, isoxaflutole applied alone or in tank-mixture with sulfentrazone/pyroxasulfone, flumioxazin/sulfentrazone, or imazethypyr/saflufenacil/pyroxasulfone provided 76 to 99% control. The above-mentioned herbicides followed by a POST of glufosinate provided similar control (91 to 99%) to a POST of glufosinate alone 14 days after early-POST. A single PRE application of isoxaflutole provided 41% control, and 63% control when followed by a POST of isoxaflutole. Similarly, 63 to 100% density reduction was achieved when glufosinate was applied POST with or without a PRE herbicide 14 days after early-POST. PRE herbicides followed by single or sequential applications of glufosinate provided 80 to 99% control. When compared to isoxaflutole PRE or isoxaflutole PRE followed by isoxaflutole early-POST, the control was 10% and 52%, respectively, 21 days after late-POST. A single POST application following isoxaflutole PRE resulted in 70% control compared to 96% control when isoxaflutole PRE was followed by two POST applications of glufosinate 70 days after late-POST. No soybean injury was observed from any herbicide program. Most herbicide programs provided similar yields to the non-treated control. Isoxaflutole tank-mixtures with sulfentrazone/pyroxasulfone PRE followed by glufosinate early-POST provided a greater yield of 2,294 kg ha^{-1} compared to other herbicide programs and the non-treated control (954 to 1,037 kg ha^{-1}). The results from this study indicate that there are herbicide programs available for effective control of glyphosate-resistant Palmer amaranth in isoxaflutole/glufosinate-resistant soybean.

TILLAGE EFFECTS ON WATERHEMP POPULATION DYNAMICS IN MICHIGAN. Scott R. Bales*[1], Christy Sprague[2]; [1]Michigan State

University, east lansing, MI, [2]Michigan State University, E Lansing, MI (43)

Common waterhemp is a new problem for Michigan soybean growers. As waterhemp populations spread to new fields, Michigan growers are looking for strategies to reduce the impact of this weed. In 2017 and 2018 field trials were conducted to investigate the effects of tillage on a common waterhemp emergence and seed bank management. Tillage treatments included: 1) fall moldboard plow followed by shallow spring tillage, 2) shallow spring tillage, and 3) no-tillage. Within each tillage system a subset of herbicide treatments were established. These treatments included: 1) high management (flumioxazin + pyroxasulfone - PRE followed by dicamba + acetochlor - POST), 2) standard management (flumioxazin + pyroxasulfone - PRE followed by dicamba - POST), and 3) no herbicide. In no-tillage treatments, the PRE also included glyphosate + dicamba control emerged waterhemp at planting. At soybean planting, fall moldboard and shallow spring tillage treatments reduced the number of common waterhemp seeds in the upper 5 cm of the soil by 85% and 40%, respectively, compared to no-tillage. Tillage treatments did not affect total common waterhemp emergence from the time of planting to harvest. However, tillage did affect the timing of common waterhemp emergence. Common waterhemp peak emergence was one wk earlier in the no-tillage treatments compared with the fall moldboard plow and spring tillage treatments. Tillage also did not affect common waterhemp control at harvest. Common waterhemp control was over 95% for high management and standard management programs. Soybean yield was only affected when common waterhemp was not controlled and yield was reduced by over 21%. From our research we did not observe a benefit to tillage in reducing common waterhemp emergence or improving common waterhemp control in the year following fall tillage. What had a greater impact on common waterhemp control was choosing an appropriate herbicide management program for controlling this weed once it is appears in a growers field.

IMPORTANCE OF RESIDUAL HERBICIDES FOR CONTROL OF GLYPHOSATE-RESISTANT PALMER AMARANTH IN DICAMBA/GLYPHOSATE-RESISTANT SOYBEAN. Adam Leise*, Parminder Chahal, Ethann R. Barnes, Amit Jhala; University of Nebraska-Lincoln, Lincoln, NE (44)

Palmer amaranth is one of the most troublesome agronomic weeds and has an extended period of emergence starting from March until October in the mid-western and southern US which makes it difficult to control in the later crop season. A Palmer amaranth biotype was reported resistant to glyphosate on a grower's farm under corn-soybean rotation near Carleton, Nebraska. A field study was conducted at the grower's site this year to evaluate the effect of soil residual preemergence (PRE) herbicides followed by a tank mixture of foliar active and residual postemergence (POST) herbicides on glyphosate-resistant Palmer amaranth control in dicamba/glyphosate-tolerant soybean. The herbicide treatments in the study were arranged in a randomized complete block arrangement with three replications including a non-treated control. At 14 d after PRE, flumioxazin + pyroxasulfone, flumioxazin + pyroxasulfone + chlorimuron, flumioxazin + pyroxasulfone + metribuzin, or flumioxazin + chlorimuron provided 78 to 99% control. The aforementioned PRE herbicides followed by a POST application of dicamba alone or dicamba tank mixture with acetochlor controlled Palmer amaranth 73 to 96% at 14 d after POST. Similarly, PRE herbicides followed by a POST application of dicamba alone or dicamba tank mixture with acetochlor showed similar Palmer amaranth density reduction of 89 to 96% at 14 d after POST. At 42 d after POST, PRE herbicides followed by dicamba alone POST or dicamba + acetochlor did not show any difference in Palmer amaranth control (72 to 96%). Soybean yield was similar (2,952 to 5,220 kg ha^{-1}) among PRE alone, PRE followed by dicamba alone or dicamba + acetochlor treatments in the study. The experimental site was under rainfed conditions without any irrigation and reduced late-season Palmer amaranth emergence occurred at the site this year which could account for the lack difference in control or soybean yield when overlapping residual herbicides were tank-mixed with foliar active POST herbicides compared to only foliar active POST herbicides application.

CONTROL OF PALMER AMARANTH WITH PREEMERGENCE DICAMBA IN SOYBEAN. Dakota Came*, Marshall M. Hay, Dallas E Peterson; Kansas State University, Manhattan, KS (45)

Palmer amaranth (*Amaranthus palmeri*) is one of the most problematic weeds throughout the southern and northcentral US. With the introduction of dicamba-resistant soybean, there has been an increase in the use of dicamba for Palmer amaranth control. While much attention is focused on POST applications of dicamba, field evidence suggests that PRE applied dicamba could provide burndown as well as residual control of Palmer amaranth. The objective of this research was to assess residual Palmer amaranth control with PRE applications of dicamba alone and in combination with residual herbicides in dicamba-resistant soybean. Field trials were implemented in 2018 near Manhattan, KS. Three separate experiments comprised this research: EXP1 consisted of six treatments of various combinations of dicamba, acetochlor, fomesafen and S-metolachlor, and EXP2 and 3 were comprised of identical treatments with combinations of two rates of dicamba alone and in combination with an acetochlor plus fomesafen pre-mixture. All three experiments occurred at different times throughout the summer and rainfall was variable for each experiment. In EXP1, dicamba, S-metolachlor, and acetochlor provided a similar level of control; however, when dicamba was tank-mixed with other residual herbicides, the best control was observed at both three and eight WAP. In EXP2, all treatments provided similar control at three and eight WAP, likely due to the timing of precipitation events. In EXP3 at eight WAP, the highest rate of dicamba (1120 g ai ha^{-1}) provided 45% control, whereas treatments that included acetochlor plus fomesafen resulted in > 97%, and the addition of dicamba did not improve control. PRE dicamba in combination with other residual PRE herbicides can improve control of Palmer amaranth depending on rainfall events and weed emergence patterns. Residual control benefits of PRE applied dicamba will most likely occur when limited rainfall for herbicide incorporation occurs after PRE application.

WEED CONTROL AND RESPONSE OF DICAMBA-RESISTANT SOYBEAN TO A PREMIX OF DICAMBA AND PYROXASULFONE. Amy D. Hauver*[1], Ethann R. Barnes[2], Brady Kappler[3], Amit Jhala[2]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]BASF Corporation, Eagle, NE (46)

Producers in Nebraska and across North America are combating mounting herbicide-resistant weed populations. In 2017, Nebraska produced 3.3 billion bushels of soybean on 2.1 million ha at a production value of three billion dollars. In 2017, dicamba-resistant soybean came to the market with the intention to improve broadleaf weed control using dicamba. Dicamba-based pre-mixtures are under development and need to be tested to evaluate their efficacy and crop safety. In 2018, a field experiment was conducted at the University of Nebraska-Lincoln at South Central Agricultural Laboratory near Clay Center, Nebraska. Herbicide treatments, including a non-treated control, were laid out in a randomized complete block design with four replications. The objective of this experiment was to measure weed control and response of dicamba-resistant soybean to a pre-mixture of dicamba and pyroxasulfone. Herbicide programs included a non-treated control, pyroxasulfone plus imazethapyr plus saflufenacil plus glyphosate with or without dicamba PRE followed by dicamba plus pyroxasulfone with or without glyphosate mid-POST at the V4 soybean stage, dicamba plus pyroxasulfone plus glyphosate early-POST at the V1 soybean stage followed by glyphosate, glyphosate plus fomesafen or dimethenamid-P, and glyphosate plus fomesafen plus dimethenamid-P late-POST at the V6 soybean stage, dicamba plus pyroxasulfone as a single PRE, sequential applications of dicamba plus pyroxasulfone plus glyphosate early- and mid-POST, and sequential applications of dicamba applied as mid- and late-POST. PRE herbicide tank-mixtures with and without dicamba provided similar control for Amaranthus spp. (96-98%), velvetleaf (92-98%), and common lambsquarters (71-92%) at 14 days after PRE. PRE followed by POST herbicide programs provided 99% control of Amaranthus spp., velvetleaf, and common lambsquarters at 100 days after planting, 100% weed biomass reduction, and yield ranging from 3,939 to 4,828 kg ha^{-1}. Although 10 to 12% damage was observed 7 days following mid-POST applications of pyrozasulfone plus glyphosate, it did not result in lower yield. The non-treated control yielded only 917 kg ha^{-1}. A single PRE of pyroxasulfone plus dicamba provided 52%, 79%, and 56% control for Amaranthus spp., velvetleaf, and common lambsquarters, respectively, at 100 days after planting, 25% biomass reduction, and yield 2382 kg ha^{-1}. A single early-POST application of pyroxasulfone plus dicamba plus glyphosate resulted in 99% control of Amaranthus spp., velvetleaf, and common lambsquarters at 100 days after planting; however, only 80% biomass reduction, and yield of 2868 kg ha^{-1}. Sequential POST applications of dicamba achieved 99% control of Amaranthus spp., velvetleaf, and common lambsquarters at 100 days after planting, and resulted in 97% biomass reduction, and yield of 3386 kg ha^{-1}. Results of this study suggest the pre-mixture of pyroxasulfone plus dicamba utilized in a PRE followed by POST or sequential POST herbicide programs is an effective tool for the control of Amaranthus spp., velvetleaf, and common lambsquarters.

WEED MANAGEMENT SYSTEMS IN XTEND FLEX SOYBEAN. Brian Stiles II*[1], Christy

Sprague[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (47)

Xtend Flex is a new soybean technology that has resistance to glyphosate, glufosinate, and dicamba. This new technology allow farmers to apply these distinctly different herbicides for weed management in soybean. In 2018, a field study was conducted in East Lansing, Michigan to evaluate crop tolerance and weed control with different weed control systems in Xtend Flex soybean. Weed control systems evaluated included: PRE flumioxazin (72 g ha^{-1}) followed by POST glyphosate (1.27 kg ae ha^{-1}), glufosinate (0.65 kg ha^{-1}), glyphosate + dicamba at (0.56 kg ae ha^{-1}), or glyphosate + dicamba + pre-mixture of fomesafen (0.25 kg ha^{-1}) + acetochlor (1.26 kg ha^{-1}); PRE flumioxazin + dicamba followed by POST glufosinate + acetochlor, or glufosinate + fomesafen + acetochlor; and POST applications of glufosinate applied twice, glyphosate + dicamba applied twice, or various timings of glufosinate and glyphosate + dicamba. Overall soybean injury was relatively low, with the greatest injury occurring seven days after POST treatments containing fomesafen (10-15%). Later planting and low rainfall in June and July resulted in low emergence (<1 weed 0.25 m^{-2}) of annual grass, common lambsquarters, Powell amaranth, common ragweed, and velvetleaf. Herbicide treatments provided excellent weed control. Soybean yield was reduced 20% when weeds were not controlled as well as the highest yielding treatment. Other treatments yielded similarly to the highest yielding treatment, with the exception of glyphosate + dicamba applied twice, 10% reduction in yield. While there was no benefit to the treatments designed to be used with the this technology under the conditions of this study, further research needs to be conducted under higher weed populations and in fields with herbicide-resistant weeds.

EFFECT OF LOW TANK-CONTAMINATION RATES OF 2,4-D AND DICAMBA ON SENSITIVE SOYBEAN YIELD, SEED VIABILITY, AND SEEDLING GROWTH. Cade Hayden*[1], Julie Young[1], Jason K. Norsworthy[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]University of Arkansas, Fayetteville, AR (48)

Dicamba-resistant soybean adoption has resulted in an increase in the potential for dicamba-sensitive varieties to be exposed to off-target dicamba movement. Tank contamination is one mechanism of dicamba exposure frequently cited in commercial herbicide applications. The impending release of 2,4-D-resistant soybean may increase the potential for soybean sensitive to 2,4-D to be exposed to off-target movement of 2,4-D. Field trials were conducted in Arkansas and Indiana in 2017 to evaluate the response of glyphosate-resistant soybean to 2,4-D or dicamba. A rate titration of 2,4-D or dicamba was applied to glyphosate-resistant soybean at either the V2 or R1 growth stage. Soybean plant height reduction and visual injury were recorded at 14 and 28 days after treatment. Plant height and grain yield were collected at soybean physiological maturity. Subsamples of soybean seed from each plot were subjected to standard seed germination tests and seedling growth characterization. Even though visual soybean injury in the field was evident at rates as low as 0.56 g ae ha^{-1} of dicamba, reductions in soybean plant height, grain yield, warm germination, cold germination, and accelerated aging germination were not observed until the dose of dicamba was increased to 56 g ae ha^{-1} at the R1 growth stage on the parent plants. Growth abnormalities exhibited during the seed germination tests and the seedling growth assay were not consistent with previous exposure to the auxin herbicides or the extent of field soybean injury. Soybean field exposure to 2,4-D did not reduce seed germination in the progeny when exposure occurred at either the V2 or R1 growth stages. In summary, reductions in seed viability were only associated with soybean plant height reductions and yield loss in the field. Furthermore, observations of abnormalities (e.g. curved radicle, malformed leaves, etc.) in seed germination or seedling growth during this testing were not consistent with auxin herbicide injury in the field.

SCREENING OF SOYBEAN VARIETY TOLERANCE TO PRE-EMERGENCE HERBICIDES SULFENTRAZONE (PPO) AND METRIBUZIN (PSII). Nikola Arsenijevic*[1], Sarah Striegel[2], Victor Hugo V. Ribeiro[2], Maxwel Coura Oliveira[2], Rodrigo Werle[2]; [1]University of Nebraska Lincoln, North Platte, NE, [2]University of Wisconsin-Madison, Madison, WI (49)

The use of soil-applied PRE-emergence herbicides has become a crucial strategy for weed management in soybeans. Farmers and agronomists are questioning whether the use of soil-applied herbicides at planting may impact early season crop development and yield potential. The objective of this study was to evaluate, under greenhouse conditions, the tolerance level of 20 soybean varieties to PSII- (metribuzin) and PPO-inhibitor (sulfentrazone) herbicides sprayed PRE-emergence at label rates on early-season soybean growth and vigor. Four seeds were planted at a 3 cm depth in the experimental units (square pots 10 cm wide and 9 cm deep) filled with field soil (silt loam, 3.1% OM, pH=6.6). Experimental units were sprayed the day of planting using a single nozzle research track sprayer calibrated to deliver 140 L ha^{-1}. Treatments consisted of metribuzin (Tricor; 560 g ai ha^{-1}), sulfentrazone (Spartan; 280 g ai ha^{-1}), and metribuzin + sulfentrazone (Authority MTZ; 302 and 201 g ai ha^{-1} of metribuzin and sulfentrazone, respectively). The greenhouse study was conducted in a completely randomized design with four replications and conducted twice. Plants within each experimental unit were visually evaluated at V2 growth stage. Evaluation scale ranged from 1 to 10, whereas 1 to 3 represented dead or highly injured plants, and above 7, healthy or uninjured. In addition, plants were harvested and dry biomass recorded. Results indicate that metribuzin had the highest impact on early-season development from most varieties tested herein, whereas sulfentrazone and metribuzin + sulfentrazone had similar and the least impact. Conversely, under field conditions (data to be presented at the conference), sulfentrazone had bigger impact on early growth stages on the same 20 varieties compared to metribuzin. Perhaps, the greenhouse screening was more conducive for metribuzin injury (e.g. higher herbicide concentration in a smaller volume of soil), but not for sulfentrazone injury (e.g. no water splashing due to rainfall events at hypocotyl emergence, common for PPO herbicide injury under field conditions). In our field study, early season crop injury did not result in yield loss. Nevertheless, greenhouse screenings can be a valuable tool in investigating the tolerance level of PRE herbicides and aid selection of varieties that can better withstand PRE herbicides during crop establishment. The weed control provided by PRE herbicides outweigh any potential concern related to reduced initial crop development (assuming herbicides are applied according to the label).

SPECTRUM OF WEED SPECIES CONTROLLED BY VARIOUS PRE-EMERGENCE SOYBEAN HERBICIDES IN WISCONSIN. Victor Hugo V. Ribeiro*[1], Maxwel Coura Oliveira[1], Daniel Smith[2], Jose Barbosa dos Santos[3], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]UW Madison NPM, Madison, WI, [3]UFVJM, Diamantina, Brazil (50)

Early-season weed control is necessary to protect soybean yield potential. The use of preemergence (PRE) herbicides, particularly in soybean where effective postemergence (POST) options are limited, is recommended for weed control during initial phases of crop establishment. The objective of this study was to investigate the weed control of eleven PRE soybean herbicides with different modes of action at two Wisconsin locations with differing weed communities. In 2018, the study was conducted at Arlington (Silty clay loam soil, pH = 6.5 and 2.6% OM; predominant weed species = common purslane and grasses) and Lancaster (Silt loam soil, pH = 7 and 2.5% OM; common lambsquarters and waterhemp), in a randomized complete block design with four replications (3 x 7.6 m plot size). Herbicide treatments consisted of imazethapyr (293 mL ha^{-1}), chlorimuron (211 g ha^{-1}), cloransulam (42 g ha^{-1}), metribuzin (752 g ha^{-1}), sulfentrazone (585 mL ha^{-1}), flumiozaxin (211 g ha^{-1}), saflufenacil (73 mL ha^{-1}), acetochlor (3507 mL ha^{-1}), S-metolachlor (1954 mL ha^{-1}), dimethenamid (1317 mL ha^{-1}), pyroxasulfone (211 mL ha^{-1}) and an untreated check. Soybeans were planted (76-cm row spacing) on June 12 and May 24 at Arlington and Lancaster. Herbicide treatments were sprayed the day after soybeans were planted using CO_2 backpack sprayer calibrated to deliver a spray volume of 140 L ha^{-1}. At 64 and 68 days after treatment at Arlington and Lancaster, respectively, the herbicide efficacy (% control based on visual observation) of each weed species present at each site were recorded. Weed biomass samples were collected, dried to constant weight at 60 C, and final biomass recorded. Biomass reduction (%) compared to the untreated check was calculated for each herbicide treatment. Herbicide efficacy varied across sites and the differential response is attributed to the weed community present at each site. For instance, group 2 herbicides were not effective controlling waterhemp but provided excellent levels of common lambsquarters control at Lancaster and excellent levels of common purslane and grass control at Arlington. Conversely, metribuzin provided excellent levels of control at Lancaster but moderate at Arlington. These results indicate that PRE herbicide efficacy is species specific. Though not effective on ALS-resistant species such as waterhemp, group 2 herbicides are still effective on a wide range of grass and broadleaf weed species commonly found in Wisconsin cropping systems and beyond. Understating the weed community present at a field is of extreme importance for proper PRE herbicide selection.

ENLIST ONE AND ENLIST DUO DOSE RESPONSE ON GLYPHOSATE TOLERANT AND NON-GLYPHOSATE TOLERANT SOYBEANS. Estefania G. Polli*[1], Kasey Schroeder[1], Jeffrey Golus[1], Bruno Canella Vieira[2], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE,

[2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (51)

2,4-D is a synthetic auxin widely used for selective weed control of broadleaf weeds in fallow and monocotyledonous crops in the United States. The introduction of commercial cultivars of soybean, cotton, and corn genetically modified with resistance to 2,4-D will increase the use and expand the application window. At low-doses injury has been reported in many sensitive crops, including soybean. Spray drift from 2,4-D + glyphosate tank-mixtures could represent greater injury potential to non-glyphosate tolerant soybean. Therefore, the objective of this study was to investigate the response of non-glyphosate tolerant soybean and glyphosate-tolerant soybean to low-doses of 2,4-D and 2,4-D + glyphosate spray solutions. Dose-response studies were conducted under greenhouse conditions in the Pesticide Application Technology Laboratory at the West Central Research and Extension Center in North Platte, Nebraska. Soybean plants (V3-V4) were sprayed with a three-nozzle Research Track Sprayer calibrated to deliver 140 L ha^{-1} using AIXR11004 nozzles at 276 kPa. A total of 12 doses of 2,4-D and 2,4-D + glyphosate were tested. A 799 g ae ha^{-1} rate of 2,4-D alone and a 757 and 804 g ae ha^{-1} of 2,4-D and glyphosate, respectively for the pre-mixture we used as the maximum rates. Each rate was half of the previous one going until the smallest rate tested. The experiment was conducted twice in a Completely Randomized design with four replications. Visual estimations of injury were collected for individual plants at 7, 14, 21 and 28 days after treatment (DAT). Above-ground biomass was harvested at 28 DAT and oven-dried (65 C) to constant weight. Biomass and visual estimations of injury were analyzed using a nonlinear regression model with the drc package in R software. 2,4-D and 2,4-D + glyphosate doses that resulted in 50% biomass reduction (GR_{50}) were estimated for non-glyphosate tolerant soybean and glyphosate-tolerant soybean using a four parameter log-logistic equation. Results indicated that lower doses of 2,4-D and 2,4-D + glyphosate had similar biomass reduction on non-glyphosate tolerant soybean. However, with elevated doses the biomass reduction by 2,4-D + glyphosate was higher when compared to 2,4-D alone. The GR_{50} value for 2,4-D alone was 503 g ae ha^{-1}, whereas the GR_{50} for 2,4-D + glyphosate pre-mixture was 227 (2,4-D) and 241 (glyphosate) g ae ha^{-1}. As expected, glyphosate-tolerant soybean had similar response for both 2,4-D and 2,4-D + glyphosate treatments with GR_{50} values of 344 g ae ha^{-1} for 2,4-D alone, and 348 (2,4-D) and 370 (glyphosate) g ae ha^{-1} for 2,4-D + glyphosate. In order to avoid symptomology on sensitive crops, it is necessary to mitigate drift of 2,4-D and 2,4-D + glyphosate from applications as much as possible.

SOYBEAN RESPONSE TO TIMING OF RYE TERMINATION. Amin I. Rahhal*, Daniel L. Atherton, Mark L. Bernards; Western Illinois University, Macomb, IL (52)

Delaying burndown of cover crops or winter annual weed cover until the time of soybean (*Glycine max*) planting can result in yield losses of over 15%. The negative effects of weed interference on crops may be triggered by light quality originating from neighboring weeds. We hypothesized that plants can sense the presence of senescing plants surrounding them and crop growth will be negatively affected by senescing weeds even when its root zone is isolated. Experiments were conducted in greenhouses located at Western Illinois University. Rye (Secale cereal) was planted into a baked clay media in 13 L plastic pails. Within each plastic pail six 3.8 cm diameter PVC pipes were installed that were filled with baked clay media where soybean were planted. Treatments included: 1) no rye cover crop, 2) rye terminated one wk before planting, 3) rye terminated at time of planting, 4) rye terminated one wk after planting, and 5) rye terminated two wks after planting. Soybean were planted at the same time. Rye planting was scheduled based on termination timing so that the rye cover at termination was similar for all treatments. Soybean growth stage and size (height, internode length, leaf size) was measured twice wk^{-1} on living plants. Light reflectance measurements were taken using an Ocean Optics HR2000CG spectrophotometer twice wk^{-1}, starting at soybean emergence and continuing until rye completely senesced in treatments. One soybean plant $bucket^{-1}$ wk^{-1} was harvested beginning at the VC soybean stage. Plants were measured for weight and root mass.

A MULTI-STATE SURVEY OF TALL WATERHEMP DISCOVERS A BROAD RANGE OF SENSITIVITY TO PPO-INHIBITING HERBICIDES AND POINTS TO MECHANISMS OTHER THAN THE ΔG210 TARGET SITE MUTATION. Brent C. Mansfield*[1], Haozhen Nie[2], Julie Young[1], Kevin W Bradley[3], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, west lafayette, IN, [3]University of Missouri, Columbia, MO (53)

Protoporphyrinogen oxidase (PPO)-inhibiting herbicides are frequently used throughout the Midwest in soybean production to manage pigweed species, such as tall waterhemp (*Amaranthus tuberculatus*). Tall waterhemp was the first weed to evolve resistance to PPO-inhibiting herbicides and has been confirmed in eight Midwestern states to date. The only previously known mechanism of resistance has been a target site mutation resulting in deletion of a glycine at position 210 on the PPX2L gene. Enhanced molecular techniques using TaqMan assays for real-time polymerase chain reaction (qPCR) have allowed scientists to quickly and accurately determine the presence or absence of herbicide target site mutations. However, tall waterhemp tissue samples submitted to university labs suspected to be resistant to PPO-inhibiting herbicides do not always receive positive confirmation of the ΔG210 deletion. To investigate these anomalies, a multi-state survey was conducted to determine the potential for alternative resistance mechanisms in tall waterhemp beyond the ΔG210 target site mutation. Greenhouse experiments beginning in fall 2016 were conducted with three discriminating rates of fomesafen to characterize the general response of 148 tall waterhemp populations from Illinois, Indiana, Iowa, Minnesota, and Missouri. Out of the 148 tall waterhemp populations, 125, or 84%, contained plants with the ΔG210 deletion. Individual tall waterhemp plants from all Midwest states sampled were also observed exhibiting a resistance response without the ΔG210 deletion. Approximately 19, 28, 75, 41, and 16% of tall waterhemp individuals tissue sampled for genotyping did not possess the ΔG210 deletion in Illinois, Indiana, Iowa, Minnesota, and Missouri, respectively. Subsequent populations were selected to represent low-, mid-, and high-level of resistance compared with two known populations containing the ΔG210 deletion. A full dose response experiment on these populations revealed that resistance ratios ranged from 1 to 44. The primary implication of this research is that one or more mechanisms other than the widespread ΔG210 deletion for resistance to PPO-inhibiting herbicides are present in tall waterhemp populations across the Midwest.

SOYBEAN RESPONSE TO SIMULATED DICAMBA DRIFT WITH VARYING APPLICATION RATES AND TIMINGS. Tyler P. Meyeres*[1], Dallas E Peterson[2], Vipan Kumar[3]; [1]Kansas State University, Manahttan, KS, [2]Kansas State University, Manhattan, KS, [3]Kansas State University, Hays, KS (54)

Dicamba was introduced to the United States in the 1960s and has a history of causing injury to non-target susceptible plants, including soybeans. Consequently, applicators and growers often avoided using dicamba around soybeans during the growing season. However, with the introduction of dicamba-resistant technology (Roundup Ready® Xtend systems) in 2017, the number of dicamba applications around soybeans during the growing season increased dramatically, resulting in widespread dicamba injury to many fields of non-dicamba-resistant (DR) soybeans. A field experiment was conducted at the Kansas State University research farm near Manhattan, Kansas in 2018 to determine the response of non-DR soybean to drift rates, timings and multiple exposures of dicamba (Engenia™). Soybean were exposed to 0.00056 g ae ha^{-1} (1/1000X), 0.0011 g ae ha^{-1} (1/500X), and 0.0056 g ae ha^{-1} (1/100X) rates of dicamba (where 1X rate = 560 g ae ha^{-1}) at V3, R1, and R3 stages of soybean growth, and multiple exposures which included V3 and R1, V3 and R3, R1 and R3, and V3, R1, and R3 growth stages. Treatments were arranged as factorial combinations in a randomized complete block design with four replications. Visual estimations of soybean injury (%) was evaluated at regular intervals through the growing season. Leaf cupping, brittle leaves, damaged terminal buds, stunting, and pod curling were observed with dicamba treatments. Stem twisting only occurred to soybeans exposed to dicamba during the R3 growth stage. Soybean injury from dicamba was lower and less persistent when exposed during the V3 than the R1 or R3 growth stages. Symptoms became more severe as dicamba rates increased and with multiple exposures. Soybean injury was most severe four wks after treatment and was highest with the 1/100X rate applied at all three timings with 80% injury. Yield reductions were not directly correlated to visual injury and were substantially less than most injury ratings. The highest soybean yield reduction occurred from the 1/100X rate of dicamba applied at V3, R1, and R3, which resulted in a 68% yield loss. Soybean yield loss was minimal from a single dicamba exposure at the V3 stage regardless of exposure rate, or from the 1/1000X rate, regardless of timing or number of exposures. The greatest soybean yield loss from dicamba occurred with multiple exposures at rates greater than 1/1000X rate of dicamba.

RELATIVE SENSITIVITY OF CONVENTIONAL SOYBEAN TO DICAMBA BASED HERBICIDES AT THREE GROWTH STAGES. O. Adewale Osipitan[1], Jon E Scott*[2], Stevan Knezevic[3]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE (55)

Widespread use of dicamba-based herbicides such as Clarity® (dicamba diglycolamine salt, 480 g L^{-1}), Engenia® (dicamba N,N-Bis-[3-aminopropyl] methylamine salt, 600 g L^{-1}) and XtendiMax® (dicamba diglycolamine salt, 350 g L^{-1}) with Vapor-Grip Technology for weed control in dicamba-tolerant (DT) crops have resulted in unintended drift, partly due to windy conditions and common temperature inversions in many parts of US. It is unclear if the dicamba-based herbicides made of different formulations or technologies have differential impact on sensitive soybeans including a conventional variety. Thus, field studies were conducted in 2017 and 2018 to evaluate the relative sensitivity of a conventional soybean to micro-rates of three dicamba-based herbicide products (Clarity®, Engenia® and XtendiMax®) applied at three soybean growth stages (V2, V7/R1 and R2 stages). The dicamba micro-rates were 0, 0.56, 1.12, 5.6, 11.2, and 56 g ae ha^{-1}; equivalent to 0, 1/1000, 1/500, 1/100, 1/50, 1/10 of the standard rate (560 g ae ha^{-1}) respectively. The experimental design was a randomized complete block design in a split-split-plot arrangement with four replications. There was no difference in visual estimation of injury, growth or yield response of the conventional soybean to the three dicamba herbicides. The dicamba micro rates caused 40-80% injury and 0-97% yield loss depending on the growth stage of application. The estimated effective doses (ED values) suggested that conventional soybeans exposed to dicamba micro-rates at V7/R1 growth stage were more sensitive than those exposed at V2 and R2 growth stages. Based on the ED values, about 0.1% of dicamba standard rate was enough to cause 10% soybean yield loss when applied at V7/R1 stage; while about 1% of dicamba standard rate was required to cause the same level of yield loss when applied at V2 or R2 stage. By implication, dicamba drift from any of the dicamba-based herbicides on sensitive soybean plants should be avoided to prevent yield loss.

IMPACT OF DIFFERENT DICAMBA HERBICIDES ON GLUFOSINATE-TOLERANT SOYBEAN. O. Adewale Osipitan[1], Jon E Scott[2], Stevan Knezevic[3], Ayse Ulusoy*[4]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE, [4]University of Nebraska, Lincoln, NE (56)

Off-target movement of dicamba is still a concern for soybean growers in Nebraska and many parts in the United States. It is unclear if low-doses of dicamba herbicides with different formulations and/or technologies have similar impact on sensitive soybeans. Field studies were conducted in 2017 and 2018 to evaluate impact of low-doses of three dicamba herbicides on Liberty-Link (glufosinate-tolerant) soybean. The three evaluated dicamba herbicides were Clarity®, Engenia® and XtendiMax®. Studies were arranged in a split-plot design with six dicamba rates (0, 1/10, 1/50, 1/100, 1/500, 1/1000 of the label rate (560 g ae ha^{-1})) applied at three timings (2nd trifoliate (V2), 7th trifoliate/beginning of flowering (V7/R1), and full flowering (R2) growth stages). There was no difference in impact of the dicamba herbicides on glufosinate-tolerant soybean. Increase in dicamba dose increased soybean injury and reduced yield for application timings. Dicamba dose of 0.30-1.38 g ae ha^{-1} caused 50% soybean injury at 21 DAT depending on the application time. The sizes of pods, number of pods, number of seeds and seed weight decreased with increased dicamba dose. Dicamba dose of 12 to 21 g ae ha^{-1} reduced yield by 50% (275 to 1900 kg ha^{-1}) depending on the crop growth stage of dicamba application. For example, 12 g ae ha^{-1} of dicama caused a 50% reduction in soybean yield (1900 kg ha^{-1}) at V7/R1 stage, compared to 21 and 16 g ae ha^{-1} dose required at V2 and R2 stage, respectively. There was a high correlation between yield reduction and plant height reduction [R2 = 0.90 (V2); = 0.94 (V7/R1); = 0.87 (R2)] when observed 28 days after dicamba exposure. A 10% soybean yield reduction was caused by 25, 18 and 12% reduction in plant height when exposed to dicamba at V2, V7/R1 and R2 stage, respectively; suggesting that reduction in plant height caused by dicamba could be a potential tool to quickly predict yield loss.

SENSITIVITY OF DT-SOYBEAN TO MICRO-RATES OF 2,4-D. O. Adewale Osipitan*[1], Jon E Scott[2], Stevan Knezevic[3]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE (57)

Enlist® technology, also known as 2,4-D-tolerant (ET) soybeans, is very new technology and was planted in Nebraska (and elsewhere) on a very limited acres in 2018 (contract production only). During these early adoption stages, the majority of soybeans planted in the US are non-ET varieties, therefore there is an obvious concern that the use of 2,4-D based herbicides will result in unintended affects from drift. In addition, it is unclear if a dicamba-tolerant (DT) soybean will be equally tolerant to 2,4-D drift, as both dicamba and 2,4-D are auxin herbicides. A preliminary field study was conducted in 2018 at Concord, NE to evaluate DT soybean response to micro-rates [0, 1/5000, 1/1000, 1/500, 1/100, 1/50, 1/10 of the label rate (1070 g ae ha^{-1})] of 2,4-D (Enlist One®) applied at V2, R1, and

R2 growth stages. Increasing 2,4-D rate from 1/5000 to 1/10 of the label rate caused 0-20%, 0-42%, and 0-57% injury at V2, R2 and R1 growth stages, respectively. Beginning of flowering (R1) was the most sensitive stage of DT-soybean to 2,4-D exposure. Exposure of the soybean to 1/10 of 2,4-D label rate (1070 g ae ha^{-1}) at R1 caused 40% yield reduction compared to 6% or no yield reduction when exposed at R2 or V2 stage, respectively. Thus, this study suggested that dicamba-tolerant soybean are sensitive to low-rates of 2,4-D, particularly at early flowering stage.

RESPONSE OF GLYPHOSATE-TOLERANT SOYBEAN TO DICAMBA BASED HERBICIDES. O. Adewale Osipitan*[1], Jon E Scott[2], Stevan Knezevic[3]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]University of Nebraska, Wakefield, NE, [3]University of Nebraska, Wayne, NE (58)

New dicamba-based herbicides such as Engenia® (N,N-Bis-(3-aminopropyl) methylamine salt) and XtendiMax® (diglycolamine salt) with VaporGrip® technology were developed to reduce dicamba volatility and drift; however, there are claims that these products can still volatilize and drift. Field studies were conducted in 2017 and 2018 at Concord, NE to evaluate glyphosate-tolerant (GT) soybean response to micro-rates [0, 1/1000, 1/500, 1/100, 1/50, 1/10 of the label rate (560 g ae ha^{-1})] of the two new dicamba products compared to Clarity® (diglycolamine salt) applied at V2, V7/R1, and R2 soybean growth stages. The GT soybean was equally impacted by the micro-rates of all three products (Clarity®, Engenia® and XtendiMax®) as measured by visual estimation of injury, height reduction, delayed physiological maturity as well as yield and yield components reduction. Increasing dicamba rate from 1/1000 to 1/10 of the label rate caused 20-80% injury with the greatest injury observed when GT soybean was treated at V7/R1 stage. The greatest reduction in plant height (65%), delay in physiological maturity (22 days) and soybean yield loss (96%) was caused by 1/10 of the dicamba label rate when applied at V7/R1 soybean growth stage. In addition, estimation of effective dose for 5%, 10% or 20% yield reduction suggested that V7/R1 was the most sensitive soybean growth stage to the three dicamba products. For example, 10% yield reduction occurred when 1.83-1.85 g ae ha^{-1} of Engenia® was applied at V2 or R2, whereas, a lower dose of 0.32 g ae ha^{-1} of Engenia® caused the same level of yield reduction when applied at V7/R1. Similar doses were estimated for Clarity® and XtendiMax®; therefore, dicamba drift should be avoided at all costs, as GT soybean was equally sensitive to low rates of all three tested products with different formulations or technologies.

EFFECTS OF DICAMBA ULTRA MICRO-RATES ON SOYBEAN YIELD: HORMESIS OR NOT? Stevan Knezevic*[1], Luka G. Milosevic[2], O. Adewale Osipitan[3], Jon E Scott[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska, Wakefield, NE (59)

There are speculations that a drift of sub-lethal or ultra-low doses of dicamba herbicides to soybean can increase the yield through a phenomenon called hormesis. Thus, there is a need to evaluate the impact of ultra micro-rates of dicamba on sensitive soybean yield. A preliminary field study was conducted in 2018 at Concord, NE. The study was arranged as a split-plot design with ten dicamba micro-rates, three application times and four replications. Dicamba rates included 0; 1/10; 1/100; 1/1000; 1/5000; 1/10000; 1/20000; 1/30000; 1/40000 and 1/50000 of the 560 g ae ha^{-1} (label rate) of XtendiMax. The three application times were V2 (2nd trifoliate), R1 (beginning of flowering) and R2 (full flowering) stages of soybean development. Yield components, which included number of pods $plant^{-1}$, seeds pod^{-1} and 100-seed weight, were estimated at physiological maturity. Yields were also collected. Based on the preliminary study, there was no evidence that the ultra-low doses of dicamba increased soybean yield when applied at early vegetative (V2), early flowering (R1) or full flowering (R2) stage of growth. Application of 1/5000 to 1/10 of dicamba label rate caused 20 to 80% injury with the greatest injury at R1. A 1/10 of the dicamba label rate could cause 23 to 78% soybean yield loss depending on the growth stage of exposure; with the greatest yield loss (78%) at the R1 stage. In general, our preliminary study suggested that there was no evidence that sub-lethal doses of dicamba could increase the yield of soybean irrespective of the growth stage of dicamba exposure, suggesting that there was no hormesis occurring.

EFFECTS OF DICAMBA ULTRA MICRO-RATES ON SOYBEAN GROWTH. Stevan Knezevic[1], Luka G. Milosevic*[2], O. Adewale Osipitan[3], Jon E Scott[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska, Wakefield, NE (60)

Widespread use of dicamba herbicides in Nebraska and many parts of US has increased cases of dicamba damage to sensitive soybeans. Therefore, there is a need to establish baseline data on potential injury and effects of ultra micro-rates of dicamba on sensitive soybean plant growth. Field studies were conducted in 2018 in Concord, NE, arranged as a split-plot design with 10 dicamba micro-rates, three application times and four replications. Dicamba rates included 0; 1/10; 1/100; 1/1000; 1/5000; 1/10000; 1/20000; 1/30000; 1/40000 and 1/50000 of the 560 g ae ha^{-1} (label rate) of XtendiMax. The three application times were V2 (2nd trifoliate), R1 (beginning of flowering) and R2 (full flowering) stages of soybean development. Leaf area index and plant dry matter were evaluated at 28 days after treatment (DAT). Plant height was measured at R5 growth stage (seed filling). Leaf area reductions caused by 56 g ae ha^{-1} (1/10 of the label rate) were 72, 83 and 18% when sprayed at V2, R1 and R2 stage respectively. Estimated doses of 1.25, 1.03 and 2.41 g ae ha^{-1} caused 50% reduction of leaf area index at R1, R2 and V2 stage respectively. Plant dry matter reduction caused by 56 g ae ha^{-1} (1/10 of the label rate) were 69, 79, and 16% and estimated doses for 50% plant dry matter reduction were 10.00, 1.87 and 5.60 g ae ha^{-1} when sprayed at V2, R1 and R2 stage respectively. Application of 1/10 of the label rate caused 36, 50 and 22% reduction in plant height, at V2, R1 and R2 stage respectively. The 1/10000 to 1/50000 of dicamba label rate did not impact soybean growth. In general, results suggested that soybean growth was most sensitive to dicamba ultra micro-rates when sprayed at R1, and least sensitive when sprayed at R2 growth stage.

CRITICAL TIME OF WEED REMOVAL IN GLYPHOSATE-TOLERANT SOYBEAN ACROSS THREE LOCATIONS IN NEBRASKA. Stevan Knezevic*[1], Pavle Pavlovic[2], O. Adewale Osipitan[3], Ethann R. Barnes[4], Clint W. Beiermann[5], Nevin C. Lawrence[6], Jon E Scott[7], Amit Jhala[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]University of Nebraska-Lincoln, Scottsbluff, NE, [6]University of Nebraska, Scottsbluff, NE, [7]University of Nebraska, Wakefield, NE (61)

Repeated use of glyphosate in glyphosate-tolerant (GT) crops caused an increase in glyphosate-resistant weed populations. Thus, there is need for diversification of weed control programs and use of pre-emergent (PRE) herbicides with alternative modes of action. Field experiments were conducted over a period of four years (2015-2018) across three locations (Concord, Clay Center and Scottsbluff) in Nebraska, to evaluate the critical time for weed removal (CTWR) in GT soybean, as influenced by PRE herbicides. The studies were laid out in a split-plot arrangement with herbicide regime as the main plot and weed removal timing as the subplot. The herbicide regimes used were either No PRE or premixture of either sulfentrazone + imazethapyr (350 + 70 g ai ha^{-1}, Authority Assist®) or saflufenacil + imazethapyr + pyroxasulfone (26 + 70 + 120 g ai ha^{-1}, Zidua PRO®). The weed removal timings were at V1, V3, V6, R2 and R5 soybean stages, as well as weed free and weedy season-long checks. The CTWR was based on 5% acceptable yield loss. The results across years and locations suggested that the use of PRE herbicides delayed CTWR in soybean. In 2017 at both Concord and Clay Center, CTWR started at V1 soybean stage without PRE herbicide, while the application of PRE herbicide (Authority Assist® or Zidua PRO®) delayed the CTWR to V7 soybean stage at Concord and V6 at Clay Center. In 2018 at both Clay Center and Scottsbluff, CTWR started at V2 soybean stage without PRE herbicide, while application of PRE herbicide delayed the CTWR to R2 and R1 soybean stage at Clay Center and Scottsbluff respectively. These results suggested that the use of PRE-herbicide in GT soybeans could delay the need for POST glyphosate by two to five wks; thereby reducing the need for multiple applications of glyphosate during the growing season.

EXTENDING CRITICAL TIME OF WEED REMOVAL IN DICAMBA-TOLERANT SOYBEAN WITH RESIDUAL HERBICIDES. Stevan Knezevic[1], Pavle Pavlovic*[2], O. Adewale Osipitan[3], Jon E Scott[4]; [1]University of Nebraska, Wayne, NE, [2]University of Nebraska-Lincoln, Concord, NE, [3]University of Nebraska-Lincoln, Linconln, NE, [4]University of Nebraska, Wakefield, NE (62)

Dicamba-tolerant soybeans were developed to provide an alternative herbicide mode of action with the use of dicamba to manage herbicide-resistant broadleaf weed species in soybean. Residual herbicides can influence how weeds compete with the crop. Thus, they can potentially extend the critical time of weed removal (CTWR) to later in the season. A field experiment was conducted in 2018 at Haskell Ag Lab, Concord, Nebraska. The experiment was laid out in a split-plot arrangement of 28 treatments (four herbicide regimes and seven weed removal timings) with four replicates. The four herbicide regimes were different combinations of pre-emergence (PRE) and postemergence (POST) treatments. These combinations were: (1) No PRE with POST Roundup PowerMax® (glyphosate), (2) PRE Warrant® (acetochlor) and XtendiMAX® (dicamba) with POST Roundup PowerMax®, (3) PRE Warrant® and XtendiMax® with POST Roundup PowerMax® and XtendiMax®, and (4) PRE Warrant Ultra® (acetochlor plus fomesafen) with POST Warrant®, Roundup PowerMax® and XtendiMax®. The seven weed removal timings were: V1, V3, V6, R2 and R5 soybean growth stage, as well as weed free and weedy season long. The CTWR (based on 5% acceptable yield loss) started at V2 soybean stage in plots without residual herbicide application. The application of residual herbicides extended the CTWR to V4, V6 or R2 depending on the type of residual herbicide applied. The greatest extension of CTWR (R2) was achieved with the PRE application of Warant Ultra® followed by a POST tank-mixture of Roundup PowerMax® XtendiMax®. The least extension of CTWR (V4) was provided by PRE of Warant® and XtendiMax® followed by a POST application of Roundup PowerMax®. In general, it can be concluded that applications of residual herbicides in dicamba-tolerant soybeans extended the CTWR.

CONTROL OF VOLUNTEER GLYPHOSATE-TOLERANT ALFALFA IN NO-TILL ROUNDUP READY 2 XTEND AND ENLIST E3 SOYBEAN. Lisa M. Behnken*[1], Fritz Breitenbach[1], Ryan P. Miller[2], Jamie Gehling[3]; [1]University of Minnesota Extension, Rochester, MN, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota Extension, Grand Meadow, MN (63)

One of the most effective methods of terminating an alfalfa (*Medicago sativa* L) stand is a combination of herbicides and tillage in the fall prior to planting the next crop. Even with fall termination, alfalfa can become a weed in the following crop. With spring termination, due to planned rotation or winter injury, the probability increases for volunteer alfalfa in the subsequent crop. Control becomes more challenging if the alfalfa is a glyphosate-tolerant variety. Corn is usually the preferred crop to plant after alfalfa. If volunteer alfalfa is a problem in corn, several herbicides including dicamba, will control it. When soybean is planted after alfalfa, most herbicide options will only suppress the volunteer glyphosate-tolerant alfalfa. Several technologies (dicamba-, 2,4-D- and glufosinate-tolerant soybean) offer alternatives for controlling glyphosate-tolerant alfalfa in soybean. In 2017, we demonstrated that most soybean herbicide options suppressed and reduced alfalfa competition by only 70%. Using dicamba in a one- or two-pass system improved volunteer alfalfa control to 90-94%, respectively. In 2018, we evaluated dicamba, 2,4-D and glufosinate herbicide systems to control volunteer alfalfa in soybean. These systems provided 92-99% control, again demonstrating that these soybean technologies offer more effective herbicide choices for control of volunteer glyphosate-tolerant alfalfa in soybean. The objective of this trial was to evaluate, compare and demonstrate the effectiveness of dicamba, 2,4-D and glufosinate herbicide systems for controlling volunteer glyphosate-tolerant alfalfa in no-till soybeans in southeastern Minnesota. A three-year old glyphosate-tolerant alfalfa stand was mowed several times in the spring to suppress the alfalfa prior to planting and provide volunteer alfalfa competition. Dicamba-, 2,4-D- and glufosinate-tolerant soybeans were no-till planted on June 4, 2018 in 76-cm rows at a rate of 368,000 seeds ha^{-1}. A randomized complete block design with four replications was used. Pre-emergence (PRE) and postemergence (POST) treatments were applied at 6.4 kph with a tractor-mounted sprayer delivering 141 L ha^{-1} at 276 kPa using TTI110015 spray tips. Twelve treatments were applied at, A) immediately after planting, B) 20-cm alfalfa, C) 36-cm alfalfa regrowth, D) 25-cm alfalfa regrowth and E) 34-cm alfalfa regrowth. The treatments were: sulfentrazone + flumioxizin (Sonic) – A / fomesafen + glyphosate (Flexstar GT) – C, Sonic - A / 2,4-D + glyphosate (Enlist Duo) – C, glufosinate (Liberty) + acetochlor + fomesafen (Warrant Ultra) - A / Liberty – C, Sonic + Enlist Duo - A / Enlist Duo – D, Enlist Duo - A / metolachlor (Everprex) + 2,4-D choline salt + Liberty - D; dicamba (Fexapan) + glyphosate (Abundit Edge) - A / Fexapan + Abundit Edge – E, Sonic + Fexapan + Abundit Edge - A / Fexapan + Abundit Edge – E, Enlist Duo - B / Everprex + 2,4-D choline + Liberty – D, Liberty - B / Warrant Ultra + Liberty – E, Fexapan + Abundit Edge -B/ acetochlor (Warrant) + Fexapan+ Abundt Edge – E, and two untreated checks. Evaluations were taken from June through July. Dicamba, 2,4-D or glufosinate systems provided over 92% control of volunteer alfalfa, compared to 58% for the Sonic / Flexstar GT system. In 2018, volunteer alfalfa control with dicamba was greater than the 2017 results (97-98% compared to 90-94%). Control with 2,4-D and glufosinate was 92-99%. The results of this study demonstrate that dicamba-, 2,4-D- and glufosinate-tolerant soybean offer effective herbicide choices for controlling volunteer alfalfa in soybean.

INJURY AND SYMPTOMOLOGY CAUSED BY SIMULATED DRIFT OF DICAMBA-CONTAINING HERBICIDES ON SOYBEAN. Rosa Soriano*[1], Guilherme Sousa Alves[2], Jeffrey Golus[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln,

North Platte, NE, [2]University of Nebraska, North Platte, NE (64)

Soybeans are naturally very sensitive to dicamba herbicide. In Nebraska in 2017, it was estimated that 20,000 ha of non-dicamba soybeans were injured due to dicamba off-target movement. However, the extent of the injury depends on the cultivar and its growth stage. Therefore, the objective of this study was to evaluate the effect of simulated dicamba drift on non-dicamba soybeans cultivars. This study was conducted in a Randomized Complete Block design with six replications and a 5 x 4 x 7 factorial (five non-dicamba tolerant soybeans, four dicamba-containing herbicides, and seven sub-lethal rates of dicamba). The cultivars used were two conventional (Asgrow A3253 and Asgrow AG2636), two glyphosate-tolerant (Hoegemeyer 2511NRR and DynaGro 39RY25), and one glufosinate-tolerant (Credenz CZ2601LL). The dicamba herbicide formulations used were Diflexx®, Xtendimax™, Engenia®, and Status®. The rates used for Diflexx®, Xtendimax™, and Engenia® were 56, 5.6, 0.56, 0.112, 0.056, 0.0112, and 0.0056 g ae ha^{-1}.For Status®, the rates were 14, 1.4, 0.14, 0.028, 0.014, 0.0028, 0.0014 g ae ha^{-1}. The applications were performed using 140 L ha^{-1} carrier volume, sprayed using a single-nozzle spray chamber, with an AI9502EVS even nozzle, positioned 83 cm above the soybean plants. During the application, the plants were at V3/V4 growth stage. At 21 days after application, visual injury and dry weight were recorded. There was no significant interaction between cultivar, herbicide, and rate. Diflexx® caused greater biomass reduction across cultivars when compared with other herbicides. However, cultivars had similar injury when using Diflexx® and Xtendimax™. The cultivars Credenz CZ2601LL and Hoegemeyer 2511NRR were more sensitive to dicamba based on biomass reduction. On the other hand, Asgrow A3253 demonstrated less sensitivity to dicamba. Soybean cultivars have different levels of sensitivity to dicamba which could mean difference in response to drift.

INFLUENCE OF APPLICATION TIMING, SURFACE TEMPERATURE INVERSIONS, AND NEW FORMULATIONS ON DICAMBA AIR CONCENTRATIONS FOLLOWING TREATMENT. Shea T. Farrell*[1], Robert N. Lerch[2], Mandy Bish[1], Kevin W Bradley[1]; [1]University of Missouri, Columbia, MO, [2]USDA, Columbia, MO (65)

Few studies have been conducted to understand the extent to which newly-labeled dicamba formulations are present in the air following application. The objectives of this research are to determine the effects of time of application, surface temperature inversions and new formulations on the concentration of dicamba detected in the air following application. A series of field experiments were conducted near Columbia, Missouri during the 2017 and 2018 soybean growing seasons. Air samplers were placed equidistantly within 6 x 31 m plots and 31 cm above the canopy prior to dicamba applications to obtain background levels of dicamba. Air samplers were removed immediately prior to dicamba application, and then returned to the treated field 30 minutes following application. Applications were made at the 1X rate for each product, and plots were a minimum of 480 meters apart. Glass fiber filters and polyurethane foam substrates (PUF plugs) from the air sampling machines were replaced at set intervals throughout the experiments, which extended up to 72 or 96 hours following application. A methanol wash was used to extract dicamba from the filter paper and PUF plugs, and HPLC-UV was utilized to detect dicamba. Results from three experiments in which Xtendimax plus VaporGrip plus glyphosate and Engenia plus glyphosate were applied at the same time on the same evening when there was not an inversion present showed that the majority of dicamba, regardless of formulation, was detected in the first 0.5 to 8 hours after treatment (HAT). The average concentration of dicamba for the Xtendimax treatment was 33.8 ng m^{-3} while that for Engenia was 25.9 ng m^{-3} at the 0.5 to 8 HAT sampling interval. By 24 to 48 HAT, the average dicamba levels had declined to less than 3.5 ng m^{-3} for each treatment. Across five experiments in which Xtendimax plus VaporGrip plus glyphosate was applied at the same time on the same evening during inversion conditions, dicamba concentrations averaged 42.9 ng m^{-3} 0.5 to 8 HAT. Spearman's correlation was used to study relationships between dicamba concentrations and environmental conditions for samples collected in the first 24 hours after treatment (n=141). A correlation coefficient of -0.6249 and -0.5572 (P<0.0001) was observed between average air temperature and dicamba concentration at 46 and 305 cm, respectively. Significant correlations (P<0.0001) were also observed for average wind speed (-0.4459), relative humidity (0.4354), and average temperature minus dew temperature (-0.4601) across samples. These results indicate that dicamba can be detected in the air following application and that dicamba air concentrations are influenced by atmospheric stability.

IMPACT OF SIMULATED DICAMBA DRIFT ON SENSITIVE SOYBEANS. Jerri Lynn Henry*[1], Jason

Weirich[2], Reid Smeda[1]; [1]University of Missouri, Columbia, MO, [2]MFA Inc., Columbia, MO (66)

Multiple glyphosate-resistant weed species have led to rapid adoption of dicamba-tolerant (DT) crops. Increased hectares of DT crops have brought increased risk of off-target movement of dicamba to adjacent, susceptible crops. Producers who experience off-target damage need a reliable predictive tool to estimate potential yield losses. Field research at two sites in Missouri was initiated to correlate dicamba concentrations to axillary meristem elongation and crop yield. Variable applications of dicamba (diglycolamine salt) concentrations were made to both V3 and R1 (0 to 300 ppm) soybean. At 21 days after treatment (DAT), interactions of dicamba concentrations and the developmental stage of the soybean revealed dicamba concentrations from 25-150 ppm had a greater effect (reduced growth) on R1 versus V3 soybeans, whereas changes in soybean growth at 0-10 and 200-300 ppm dicamba were not different due to timing of application. Yield reductions of 8 and 49% were found with as little as 10 ppm and as much as 300 ppm dicamba exposure, respectively. Additionally, yields were reduced approximately 10% when soybeans were exposed at V3 versus R1. Reduction of apical meristem growth 21 DAT and soybean growth stage at time of exposure were found to be an accurate predictor of soybean yield at harvest (R2=0.59): (yield kg ha^{-1} = 3000.47 + (44*apical meristem growth (cm)) + (1000*soybean developmental stage (V3=1 or R1=2))). Off-target movement of dicamba can result in yield reduction with as little as 0.025% of the use rate (0.65 kg ae ha^{-1}) of dicamba.

HERBICIDE PROGRAMS FOR MANAGING GLYPHOSATE- AND DICAMBA-RESISTANT KOCHIA IN ROUNDUP READY 2 XTEND SOYBEANS. Vipan Kumar*[1], Prashant Jha[2], Phillip Stahlman[1]; [1]Kansas State University, Hays, KS, [2]Montana State University, Huntley, MT (67)

Evolution of kochia with multiple resistance to glyphosate and dicamba has become a serious management concern in the US Great Plains, including Kansas. The main objective of this research was to evaluate and develop effective herbicide strategies (multiple site of actions) for managing kochia with multiple resistance to glyphosate and dicamba in Roundup Ready® 2 Xtend soybeans. A field study was conducted in 2018 at the Kansas State University Agricultural Research Center (KSU-ARC) near Hays, KS. Experiments were conducted in a randomized complete block design, with four replications. Fifteen different herbicide programs, including pre-emergence (PRE) alone and PRE followed by (fb) postemergence (POST) were evaluated. PRE treatments were applied with glyphosate at 1260 g ha^{-1}; whereas, POST treatments were a mixture of glyphosate at 1260 g ha^{-1} and dicamba (Engenia™) at 560 g ha^{-1}. Prior to soybean planting, experimental plots were uniformly infested with a glyphosate- and dicamba-resistant kochia population. Among tested PRE programs, a single application of sulfentrazone alone or with dicamba, metribuzin + flumioxazin + imazethapyr, and pyroxasulfone + flumioxazin provided complete, season-long control of glyphosate- and dicamba-resistant kochia. Furthermore, PRE applied pyroxasulfone alone or with dicamba, dicamba alone, sufentrazone + pyroxasulfone, and sulfentrazone + metribuzin fb POST dicamba + glyphosate treatments also provided 95 to 100% season-long kochia control. Addition of dicamba to pyroxasulfone PRE improved kochia control to 82% compared with 57% control of pyroxasulfone alone PRE at nine wks after PRE (WAPRE). A single PRE application of dicamba or pyroxasulfone alone only had 70 to 78% kochia control at nine WAPRE. Consistent with visual control, kochia biomass at harvest was reduced by > 92% with majority of the treatments, except with pyroxasulfone alone (59% reduction), dicamba alone (76% reduction) or pyroxasulfone + dicamba (88% reduction) PRE treatments. Soybean yield for majority of the tested PRE and PRE fb POST herbicide programs did not differ, and ranged between 1466 and 1581 kg ha^{-1}. In conclusion, the effective PRE herbicide options evaluated in this research can serve as foundation for managing glyphosate- and dicamba-resistant kochia in Roundup Ready 2 Xtend® soybean.

INFLUENCE OF WHEAT COVER CROP ON WATERHEMP CONTROL IN AN XTEND SOYBEAN SYSTEM. Alexander Mueth*[1], Madison Decker[1], Karla L. Gage[1], Ron Krausz[2]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (68)

Herbicide-resistant weeds are a major problem across the globe in multiple cropping systems, including soybean (*Glycine max*). As a result, weed management costs have increased in order to maintain season-long weed control. Multiple herbicide-resistant biotypes of common waterhemp (*Amaranthus tuberculatus*) are prevalent across the Midwest. The lack of novel herbicide sites of action necessitates investigation of innovative nonchemical weed control practices. A field study was initiated in Belleville, Illinois investigating a novel approach to cultural weed control by inter-seeding winter wheat

(*Triticum aestivum*) in soybeans for the suppression of common waterhemp. Traditional PRE followed by POST herbicide programs were compared to the inter-cropping treatments in regards to weed control. The winter wheat was terminated when the soybeans reached the V5 growth stage, and this allowed for adequate winter wheat biomass accumulation. Visual weed control ratings were taken at 7, 14, 28, and 56 days after treatment (DAT). The PRE followed by POST program of fomesafen plus S-metolachlor followed by glyphosate plus dicamba provided 99% control of common waterhemp at 56 DAT, which was not different than the common waterhemp control provided by the inter-seeding of winter wheat followed by glyphosate plus dicamba. These data suggest that the inter-seeding of winter wheat into a soybean crop, in combination with herbicide, may provide a potential alternative to manage common waterhemp. Further studies to determine the best agronomic practices to mitigate competition of inter-seeded winter wheat in a soybean crop should be investigated.

POST HERBICIDE EFFICACY AS INFLUENCED BY SEVERITY OF WATERHEMP INJURY FROM PRIOR HERBICIDE APPLICATIONS. Jesse A. Haarmann*, Bryan G. Young, William G. Johnson; Purdue University, West Lafayette, IN (69)

Field data from 2017 and 2018 suggests that weed control can be maximized by using optimal respray timings, which vary depending on which herbicide is used and which weed species are present. Efficacy was generally maximized when a respray application was applied 7-11 days following initial application. It was also observed that weed response to failed herbicide application is variable with some plants resuming growth relatively quickly and others being more delayed in resuming growth after initial application. We hypothesized that efficacy of a respray application will be maximized where there is sufficient live tissue for herbicide absorption, but not so much that a full recovery has been made. To test this hypothesis, tall waterhemp (*Amaranthus tuberculatus*) plants were sprayed with six rates of glufosinate (0, 100, 150 200, 250, and 300 g ai ha^{-1}) to create a gradient of plant responses. Sequential applications of no herbicide, glufosinate (200 g ai ha^{-1}), fomesafen (80 g ai ha^{-1}), lactofen (40 g ai ha^{-1}), 2,4-D (200 g ai ha^{-1}), and dicamba (140 g ai ha^{-1}) were made seven days later. Live tissue present at the time of the sequential application (green area) was quantified with image J analysis and regressed against biomass for each sequential herbicide group. Green area was highly correlated with visual control and height at the same assessment timing (R2 = 0.89). For sequential herbicide groups, plants with the greatest green area resulted in the greatest final biomass and plants with the greatest level of injury resulted in the lowest biomass. These results are in disagreement with the hypothesis where it was expected that biomass of the plants receiving no herbicide on the initial application would suffer greater biomass reduction than plants receiving an initial herbicide application. Respray applications in a field setting after glufosinate will have the greatest efficacy when surviving weeds are severely injured. The decision to make a respray application should not be based on the appearance or amount of regrowth, but rather the amount of time after the failed application. For contact herbicides is this is 7-11 days and for synthetic auxin herbicides, this is 3-7 days. This research can help growers and applicators make a more informed decision about herbicide optimum timing of herbicide respray applications in the event of herbicide failure.

APOMIXIS OR AUTO-POLLINATION? SEED PRODUCTION IN ISOLATED *AMARANTHUS TUBERCULATUS* FEMALES. Brent P. Murphy*[1], Patrick Tranel[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL (70)

Seed production often requires the sexual recombination of male and female gametes. For dioecious species, such as *Amaranthus tuberculatus (Moq.) Sauer*, two plants are often required for seed production: a pollen-donating male, and a pollen-receiving female. This requirement for multiple plants for progeny generation may be disadvantageous for colonization. Isolated *A. tuberculatus* female plant are routinely documented to produce seed, suggesting only one, albeit female, plant is required for seed generation. Two hypotheses have been proposed to explain this phenomenon: seed generation from an asexual origin, termed apomixis or agamospermous, and the spontaneous generation of male flowers allowing sexual recombination, termed auto-pollination. The generation of male flowers on otherwise female plants has been documented in some cases. Under the apomixis hypothesis, the progeny of the isolated female plant originates from a somatic cell, and a heterozygous genotype will be maintained across generations. Under the auto-pollination hypothesis, sexual recombination results in the segregation of a heterozygote. Segregation analysis was used to test these hypotheses. Female *A. tuberculatus* plants, heterozygous for the ΔGly210 deletion of PPX2L were crossed under pollen containment and progeny assayed for marker segregation. Segregation at this locus was observed in the progeny, supporting the auto-pollination hypothesis. These results provide insight into how *A. tuberculatus* may offset colonization penalties associated with dioecy.

INFLUENCE OF NITROGEN RATE AND FORM ON PALMER AMARANTH GROWTH. Lindsey Gastler*, Anita Dille; Kansas State University, Manhattan, KS (71)

Understanding the dynamics of a weed species' growth and development and its interactions with its environment are keys to creating an effective weed management strategy. Regarding problematic weeds like Palmer amaranth, it is especially important to create a multi-faceted approach to combat characteristics like rapid growth and development, as well as high fecundity. Questions have arisen concerning the interactions between nitrogen fertilizer and the growth and development of Palmer amaranth. To begin answering this question, a model was created to examine one piece of the puzzle, that is, the population dynamics of Palmer amaranth in response to varying control levels and potential gender ratios, specifically measured by seed production. To create the model, data from previous research studies was collected on Palmer amaranth emergence, fecundity, and seed viability. Three control levels of 85, 95, and 99% and three gender ratios of male to female of 50:50, 60:40, and 75:25 were assessed over a time span of 10 seasons. The initial seedbank was 100 seed m^{-2}. Higher levels of control such as 99% resulted in greater seed production from a lack of competition by neighboring plants, whereas lower control levels such as 85%, led to fewer seed m^{-2} being predicted. The greatest male to female ratio, 75:25, led to the greatest number of seed m^{-2} compared to the 11 and 18% decrease for the 60:40 and 50:50 ratios. To further develop this model, more investigation is needed to understand the competition between male and female plants regarding seed production, as well as Palmer amaranth emergence, fecundity, and seed viability in varying cropping systems. To continue investigating the question of nitrogen fertilizer and Palmer amaranth interactions, further study is needed on the influence of nitrogen rate and form on Palmer amaranth survival and gender ratios to better understand a potential tool for reducing weed seed production.

WATERHEMP SEED PRODUCTION AND VIABILITY FOLLOWING DICAMBA APPLICATION DURING VEGETATIVE OR FLOWERING GROWTH STAGES. Allyson M. Rumler*[1], Brent Heaton[2], Mark L. Bernards[1]; [1]Western Illinois University, Macomb, IL, [2]Western Illinois University, Industry, IL (72)

Waterhemp (*Amaranthus tuberculatus*) has evolved resistance to multiple herbicide mechanisms of action, resulting in it becoming the most problematic weed for many producers across the Midwest. Dicamba-resistant soybeans (*Glycine max*) have been rapidly adopted to manage herbicide-resistant waterhemp populations. However, every dicamba application includes the risk that some waterhemp plants will be exposed to sub-lethal doses of dicamba and may survive to produce viable seed. Greenhouse studies were conducted to evaluate the effect of sub-lethal dicamba doses when applied to vegetative or flowering waterhemp. For vegetative dicamba applications, there was 10 replications and six dicamba doses: 560, 280, 140, 70, 18.4 and 0 g ae ha^{-1}. The study was repeated in time. For flowering dicamba applications there was 14 replications and six dicamba doses: 1120, 560, 280, 140, 35 and 0 g ae ha^{-1}. In the vegetative application study, visual injury estimates, gender, and mortality was assessed. After senescence, all waterhemp was harvested by hand, threshed, weighed, and stored in fridge until germination studies began. Germination was tested by placing waterhemp seeds on moistened filter paper in sealed containers in growth chamber at 29.5 C. Viability was tested by placing waterhemp seeds in a petri-dish filled with deionized water, wrapped with parafilm and placed in a growth chamber at 29.5 C. Waterhemp seeds were then dissected longitudinally, placed on a filter paper in a container moistened with 1 mL of tetrazolium solution, and allowed to incubate for 48 hours at room temperature. After 48 hours, waterhemp seeds were evaluated to determine viability by the indication of a pink embryo. Data from the first run of the vegetative application study showed that injury increased as dicamba dose increased. However, waterhemp mortality was not affected by plant size at application or dicamba doses 280 g ha^{-1} or less. Among the plants that survived dicamba, the proportion that produced seed was roughly equal to the proportion that did not have seed, leading us to conclude that dicamba application does not prevent seed production. In addition, seed weight $plant^{-1}$ was equal across dicamba doses, and dicamba dose had no effect on seed germination or viability.

DIOECY IN AMARANTH: WHY ARE THERE FEMALE-SPECIFIC DNA SEQUENCES? Jacob S. Montgomery*[1], Ahmed Sadeque[1], Darci Giacomini[1], Patrick Brown[1], Patrick Tranel[2]; [1]University of

Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL (73)

Members of the Amaranthus genus have become some of the most notable weeds of row crop production in the US. Their ability to evolve resistance to multiple herbicides has led to weed managers considering other, more novel methods of control. One such method involves the manipulation of gender ratios in the field. This could be done by identifying the genetic determinant of sex and using it to skew the gender ratio in favor of males. By reducing the number of females, the number of seeds produced each year will be decreased. In search for this genetic basis of sex determination in Amaranthus, restriction site associated DNA sequencing (RAD-Seq) was conducted on waterhemp (*A. tuberculatus*) and Palmer amaranth (*A. palmeri*) plants to locate any gender-specific regions. Given that males are known to be the heterogametic sex, male-specific sequences were expected and found. These sequences are assumed to be linked to a male-specific Y region that represses female flowers and promotes male flowers. Surprisingly, female-specific sequences were also detected in some, but not all, female waterhemp plants. We hypothesize that these female-specific sequences may belong to a non-functioning remnant of a male Y-chromosomal region (herein referred to as the Y' region). We further hypothesize that offspring from a mother plant with this Y' region will have skewed gender ratios, because the Y' region lacks the necessary genetic information that would be found on the X chromosomal region, making YY' progeny non-viable. To test this hypothesis, we generated and validated a Y' region-specific marker and used it to select female plants carrying the Y' region. This poster presents an experimental design that utilizes progeny gender ratios and marker inheritance to investigate female-specific sequences in waterhemp. A deeper understanding of these female-specific reads would unlock further insights into the realm of gender determination in weedy Amaranthus species.

TIME OF JOHNSONGRASS (*SORGHUM HALEPENSE*) SEEDLING EMERGENCE IN NEBRASKA. Don G. Treptow*[1], Rodrigo Werle[2], Amit Jhala[3], Melinda Yerka[3], Brigitte Tenhumberg[1], John Lindquist[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska, Lincoln, NE (74)

Knowledge on the emergence pattern of weed species is of extreme value when developing weed management programs. This information is also required when attempting to model weed population dynamics and herbicide resistance evolution. A model predicting ALS-inhibiting herbicide resistance evolution of Johnsongrass populations can help producers make responsible management decisions to slow or prevent this evolution from taking place. The seedling emergence pattern of multiple Johnsongrass populations was examined at two locations in Nebraska. A field experiment was conducted at the UNL – Eastern Nebraska Research and Extension Center near Mead, NE and at the UNL – Havelock Farm, Lincoln, NE from 2016 through 2018 (four site-years). The study was conducted as a two-way factorial on a randomized complete block design with four replications. Johnsongrass population and predation basket type were the two treatment factors. Johnsongrass population and predation basket type were the two treatment factors. Seed populations from Johnsongrass populations collected from corn, soybean, sorghum and fallow cropping systems throughout the Midwest were used for this experiment. Initial viability of the seed populations was tested using a germination chamber and the tetrazolium test. Mesh baskets were buried in the fall and two hundred seeds of each population were placed on the soil surface of each basket. Predation baskets went without lids while non-predation baskets had mesh lids installed. For examining Johnsongrass seedling emergence, a set of non-predation baskets overwintered and had lids removed in early April, and Johnsongrass emergence was recorded weekly throughout the growing season. Soil moisture and temperature were collected at depths of 2 cm and 5 cm for each site to test for correlation with Johnsongrass seedling emergence. The data collected will be used as parameter values for a risk-assessment model simulating Johnsongrass population dynamics under different crop rotations and herbicide programs.

POST-DISPERSAL FATE OF JOHNSONGRASS (SORGHUM HALEPENSE) SEEDS IN NEBRASKA. Don G. Treptow*[1], Rodrigo Werle[2], Amit Jhala[3], Melinda Yerka[3], Brigitte Tenhumberg[1], John Lindquist[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska, Lincoln, NE (75)

Knowledge on post-dispersal seed fate of weed species is necessary when attempting to model population dynamics and herbicide resistance evolution. A model predicting ALS-inhibiting herbicide resistance evolution of Johnsongrass populations can help producers make responsible management decisions to slow or prevent this evolution from taking place. Johnsongrass fall and spring seed predation and decay, seed winter survival, seedling emergence, and growing season seed survival of multiple populations were examined at two locations in Nebraska. Field experiments were conducted at the UNL – Eastern Nebraska Research and Extension Center near Mead, NE and at the UNL – Havelock Farm, Lincoln, NE from 2016 through 2018 (four site-years). The study was conducted as a two-way factorial on a randomized complete block design with four replications. Johnsongrass population and predation basket type were the two treatment factors. Seed populations from Johnsongrass collected from corn, soybean, sorghum and fallow cropping systems throughout the Midwest were used for this experiment. Initial viability of the seed populations was tested using a germination chamber and the tetrazolium test. Mesh baskets were buried in the fall and 200 seeds of each population were placed on the soil surface of each basket. Predation baskets went without lids while non-predation baskets had mesh lids installed. A number of predation and non-predation baskets were collected in early January and some were collected in early April to assess fall and spring seed predation and decay as well as seed winter survival. Seeds were extracted by being washed, counted, and tested for viability. Another set of non-predation baskets had lids removed in early April and Johnsongrass emergence was recorded weekly throughout the growing season. These baskets were collected in mid-September and seeds were extracted and tested for viability. The data collected will be used as parameter values for a risk-assessment model simulating Johnsongrass population dynamics under different crop rotations and herbicide programs.

THE WEEDINESS OF POLLINATOR HABITAT IN AGRICULTURAL FIELD BORDERS 3 YEARS AFTER ESTABLISHMENT. Samuel N. Ramirez*, David F. Barfknecht, Karla L. Gage; Southern Illinois University, Carbondale, IL (76)

Pollinator populations have been declining for the past few decades. Federal conservation programs and non-profit organizations now offer support and incentives for pollinator habitat creation. Agricultural producers may take marginal agricultural land out of production or may use field margin areas to establish pollinator habitat. However, conservation habitats may also contain weed species of economic concern. Generally, it is assumed that these conservation plantings of native species are competitive against agricultural weeds after establishment. However, the transition of these plantings to full establishment may take several years. The objective of this study is to assess the weediness of three native seed mixtures three years after establishment. Native plant seed mixtures were established at three field sites, along the edges of agricultural fields, in Belleville, Illinois at the Bellevillle Research Center (BRC), Dowell, Illinois at the Kuehn Research Center (KRC), and Milstadt, Illinois at Henry White Research Farm (HWF). Plots were seeded in April of 2016 with three different seed mixtures in 5 m by 15 m plots and replicated three times at BRC and KRC. Triangular-shaped plots were seeded at HWF and replicated two times. Three seed mixtures were used, along with one unseeded treatment, which was intended to allow weeds to emerge without competition from the native seed mixtures, to serve as a control or reference treatment. Seed mixtures were designed to include only local, native species. The first seed mixture was broadleaf plants (BL) only, with 31 species planted at a densities ranging from 0.05 to 0.43 seeds m^{-2}, depending upon seeding density recommendations for each species. The second seed mixture was a combination of eight broadleaf plants, which would provide floral resources throughout the growing season, planted at 0.01 to 0.64 seeds m^{-2}, and five native grass species, planted at 0.19 to 1.02 seeds m^{-2} (BLG). The third seed mixture was five species of native grasses only, planted at 0.21 to 1.92 seeds m^{-2} (G). These different species assemblages were used with the hypotheses that the BL mixture would provide the greatest resources to pollinators but might be more easily invaded by other broadleaf weed species, while the G mixture would potentially provide the greatest suppression of broadleaf weeds but would not support pollinators. The intermediate BLG treatment would potentially provide pollinator resources and weed suppression benefits, and would be a lower-cost alternative for agricultural producers. The ground was prepared with a burndown application of glyphosate in the fall of 2015. Dead, standing biomass was mowed, and the soil was lightly disturbed before seeding. Plots were seeded in early April of 2016. Plots were managed by mowing in the fall in 2016 and 2017. Plots were surveyed in August of 2018 to determine establishment of native species and weediness. The BRC and KRC plots were surveyed by establishing transects at 1.5, 4.5, 7.6, 10.5, and 13.7 m. Along each transect, species were identified and individuals of each species were counted in three 0.5 m^2 subplots. The triangular HWF plots were surveyed by using an equal number of random 0.5 m^2 quadrat throws, as compared to the BRC and KRC plots. Surveyed species were placed into categories of: volunteer (further divided into grass or broadleaf), planted, and “driver” weed.

Driver weeds were defined as species that drive management actions within the agricultural field and may be difficult to control or have known herbicide resistances within the geography. The driver weeds identified were: velvetleaf (*Abutilon theophrasti* Medik.), common waterhemp (*Amaranthus tuberculatus (Moq.) Sauer*), common ragweed (*Ambrosia artimisiifolia* L.), giant ragweed (*Ambrosia trifida* L.), marestail (*Conyza canadensis* (L.) *Cronq*.), ivyleaf morningglory (*Ipomoea hederacea* Jacq.), prickly sida (*Sida spinosa* L.), giant foxtail (*Setaria faberi* Herrm.), yellow foxtail (*Setaria pumila* (Poir.) Roem. & Shult.), and Johnsongrass (*Sorghum halepense* (L.) *Pers.*). The individuals in each category were averaged across transects and plots to give one density value treatment^{-1} replicate field^{-1}, and these were used to calculate a percentage of total individuals or stems counted per treatment replicate. These values, as well as individual species abundances of driver weeds, were analyzed using a two-way Analysis of Variance (ANOVA) with site and treatment (seed mixture) as independent variables. The percentage of volunteer species found did not differ across site, but did differ across treatments; BL, BLG, and G treatments were not different from one another but had 30% fewer volunteers than the weedy control. Occurrence of volunteer grasses differed across site and treatment; KRC had a greater density of volunteer grasses than BRC and WHF, and the seeded treatments had fewer volunteer grasses than the weedy control but were not different from one another. The occurrence of volunteer broadleaf species was different across sites but not treatments, with the least occurrence at KRC. Driver weed abundance was different across sites and treatments; the WHF site had the lowest occurrence of driver weeds, and the weedy control had the greatest abundance, while the BL, BLG, and G treatments were not different from one another. These results suggest that any one of the seed mixtures is able to suppress volunteer species and driver weeds. This suppression did not occur to the degree that agricultural producers should be unconcerned about the potential for weed problems in pollinator plantings after establishment and subsequent seed dispersal to and from the agricultural field. The site-specific differences observed may be related to the weed pressure within the adjacent agricultural field. This suggests that agricultural producers who implement pollinator conservation practices near agricultural fields may need to plan for management of weedy species-of-concern for up to three years or more following the establishment of conservation plantings. The establishment of the plantings in this study may have been improved by fall-seeding or frost-seeding, rather than spring-seeding, and would have benefited from intensive early management. Improved establishment would likely further decrease the presence of volunteer species.

ROLE OF COVER CROPPING AND HERBICIDE USE ON MARESTAIL CONTROL: A REGIONAL PERSPECTIVE. Ryan J. Collins*, Erin Haramoto; University of Kentucky, Lexington, KY (77)

Application of sustainable weed management practices in agronomic crops will be one of the largest challenges farmers face in the future. Marestail (*Conyza canadensis* L.) is a problematic weed in row crops where management can be challenging. The life cycle of marestail is rather complex, and shifting emergence patterns have further complicated management. The goal of this project is to examine the biological nature of marestail across a broad region (KY, IL, MO and KS) to provide a regional model for managing this difficult weed. The impact of management practices, including cover crops and herbicides, were examined on marestail in a no-till corn / soybean rotation. Weed management treatments for this project include fall-planted cover crops (over-wintering and winter-killed), with and without herbicides, and herbicides that are applied in late fall, mid-spring or both. These fall and spring applied herbicides have different lengths of residual activity, and treatments were compared to an untreated and weed-free control. Both fall and spring applied herbicides are examined due to the ability of marestail to emerge in the fall and successfully over winter. Two permanent quadrats were established in each plot where the number of emerged marestail seedlings were counted. Plants were removed after being counted to ensure accuracy. These counts began after the establishment of cover crops and were continued until the soybean harvest the next year. Other data measurements were collected inside each plot where up to ten marestial rosettes were flagged, and measured. Diameter of the flagged marestail plants were measured weekly, and after these plants bolted, height measurements were taken weekly as well. Seedling emergence was summed over two periods to determine cumulative emergence. These two segments include prior to crop planting, and between crop planting and harvest. Cumulative emergence, both prior to planting and between planting and harvest, showed similar treatment responses across states. Kansas had the highest cumulative emergence prior to planting. The rye cover crop, with no herbicides, reduced collective marestail emergence by over 50% compared to untreated plots. The addition of flumioxazin and chlorimuron reduced marestail emergence from 12 plants m^{-2} to 5.5 plants m^{-2}, when applied with growth regulators. In both KY and IL, marestail that survived winter had similar rosette diameters across treatments. However, the number of rosettes available for tracking was limited and restricted comparisons across treatments. In KS, rosettes in treatments with a cereal rye cover crop and no fall herbicides had fewer leaves than rosettes in treatments with no herbicides. The weed-free control in IL had higher yields than some of the other treatments. In both KY and IL, treatments increased yield relative to the untreated control, and the yield at each state was similar across the various cover crop and herbicide treatments. Combined with companion experiments that characterize marestail emergence time and over-wintering success, and efforts to model important factors that regulate marestail emergence, these results will provide valuable information on best management practices for fall- and spring-emerging cohorts of this weed.

"COVER CROP LITE" REDUCES SUMMER ANNUAL WEED DENSITY AND BIOMASS IN SOYBEAN. Erin Haramoto*; University of Kentucky, Lexington, KY (78)

Residue from winter annual cover crops contributes to weed management in summer annual crops by suppressing weed emergence and reducing growth of weeds that successfully emerge. There is typically a negative relationship between the amount of residue and number of emerged weeds, though low amounts of residue can increase emergence in dry conditions. A large amount of residue (8,000-10,000 kg ha^{-1}) is needed to provide sufficient weed suppression until canopy closure in soybean. Many growers, however, prefer to practice “cover crop lite” and terminate cover crops before this much residue is produced—whether to alleviate physical planting concerns, reduce incidence of pests like slugs, or to ensure early planting dates. In herbicide-based systems, weed management benefits still likely result from low to moderate amounts of residue. A field experiment was conducted over three seasons (2016-2018) in Lexington, KY, to determine the relationship between cover crop biomass and weed density in the subsequent soybean crop in which weeds were managed with herbicides. Cereal rye and wheat cover crops were sown the previous fall following corn harvest. Different seeding rates were used and seed was either drilled or broadcast—these resulted in a range of biomass production by the two species. Cover crops were chemically terminated in mid- to late-April (Feekes 10-10.1), with soybeans planted approximately 2-5.5 wks after termination. Fomesafen and glyphosate were applied at planting, and cloransulam plus glyphosate was applied approximately 3.5-5 wks after planting. Weed density was measured 1-2 wks after planting (4-7 weeks after cover crop termination) and again prior to the POST application (5.5-10.5 weeks after cover crop termination); weed density and biomass was also measured prior to soybean harvest. Both linear and exponential decay models were used to examine the relationship between weed density and cover crop biomass. Weed density after planting and prior to the POST application was pooled as there was no interaction between sampling time and biomass. Years were analyzed separately. Cover crop biomass prior to termination ranged from < 250 to > 4000 kg ha^{-1}—well below the threshold needed for adequate season-long weed suppression without herbicides. An exponential decay function best described the relationship between weed density and cover crop biomass. Precipitation was well above normal during this period in all three years of the study, and there was no indication that low amounts of residue increased weed emergence. These results suggest that growers utilizing herbicides for weed control are still receiving benefits from low to moderate amounts of cover crop biomass. Reductions in density of weeds that must be controlled with POST applications is an important aspect to resistance management.

EFFECTS OF RYE TERMINATION TIMINGS ON SOYBEANS. Luke Chism*[1], Kraig Roozeboom[1], Gretchen Sassenrath[2], Anita Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Parsons, KS (79)

The use of cover crops for weed management have become widely adopted because of the continual evolution of herbicide-resistant weeds and the need to have integrated weed management strategies. There is a need to understand the management of cover crops such as time or growth stage of terminating an overwintering cover crop relative to the planting date of the succeeding cash or main crop. There are two perspectives on when to terminate such a cover crop. In Kansas, concerns arise when the cover crop has used up required soil moisture for the succeeding main crop. If the cover crop is terminated early more moisture will be available for the succeeding crop, while if terminated late, more cover crop biomass would be produced, but may delay main crop growth as well as giving more soil moisture retention towards the end of the season, possibly allowing for a late maturing crop to thrive. Our objective is to determine the impact of three different termination timings of winter rye cover crop on subsequent soybean growth and yield across Kansas. Five field experiments were conducted across the state. Winter rye cover crop was planted in the fall of 2017 in farmers' fields and were planted to soybean in the spring of 2018. The experiments were designed as a randomized complete block with four replications. The treatments were terminating rye with post herbicide at three different times, which were 12 to 15 days prior to soybean planting, the day of planting, and 5 to 7 days after planting. Soybean growth was observed in all locations 20 to 25 days after planting. The first two termination timings displayed soybeans at V3 stage while the third termination timing displayed soybeans at stage V2. An additional observation was made in August during the later reproductive stages. The first two termination timings displayed soybeans at R6 while the last termination timing displayed soybeans at R5. Soybeans were hand harvested on a 6.1 m^2 $plot^{-1}$ basis and yield was recorded at kg ha^{-1}. Average yield across treatments varied at each location but there were no yield differences between the three treatments in any of the five locations.

INFLUENCE OF MANAGEMENT DECISIONS RELATING TO COVER CROPS ON WEED SUPPRESSION: A META-ANALYSIS. O. Adewale Osipitan[1], Anita Dille*[2], Jon E Scott[3], Stevan Knezevic[4]; [1]University of Nebraska-Lincoln, Linconln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska, Wakefield, NE, [4]University of Nebraska, Wayne, NE (80)

The effectiveness of cover crops for weed suppression in cropping systems depended on management approaches used for both the cover crop and main crop. A previous systematic and meta-analysis review showed that there were many differences in the ability of cover crops to suppress weeds. This current meta-analysis provided a quantitative review on how cover crop and main crop management practices could influence the impact of cover crops on weed suppression. The meta-analysis used a total of 790 observations from 53 studies published between 1990 and 2018 to summarize effect sizes of cover crop management practices as they relate to weed suppression using weighed mean response ratios (R*). Cover crop biomass inversely explained the level of weed biomass (r^2 = 0.65) and weed density (r^2 = 0.59). In general, the meta-analysis showed that cover crop could provide a range of weed suppression depending on management decisions such as choice of cover crop species, cover crop sowing season (fall or spring), sowing dates within seasons, seeding rate, termination date, delay in main crop planting date after cover crop termination, tillage system under which cover crop was produced, and integrating cover crop with other weed control inputs. For example, grass cover crop species provided greater weed suppression than broadleaf species. Fall-sown cover crops provided greater weed suppression (R* = 0.19) compared to spring-sown cover crops (R* = 0.48) by the summer. Weeds were suppressed by increasing seeding rate of cover crop from 1X (R* = 0.50) to 2X (R* = 0.27) or 3X (R* = 0.10). In addition, cover crops provided greatest weed suppression in conventionally tilled systems (R* = 0.18) and reduced-tillage systems (R* = 0.13) compared to no-tillage (R* = 0.29). The main crop yield was not evaluated in this study; hence, the beneficial influence of management decisions on weed suppression should not be interpreted to mean a corresponding influence on main crop yield.

CHARACTERIZING HORSEWEED EMERGENCE PATTERNS FROM POPULATIONS ACROSS FOUR STATES. Larry J. Rains*[1], Karla L. Gage[2], Erin Haramoto[3], Reid Smeda[4], Anita Dille[1]; [1]Kansas State University, Manhattan, KS, [2]Southern Illinois University, Carbondale, IL, [3]University of Kentucky, Lexington, KY, [4]University of Missouri, Columbia, MO (81)

Predicting when horseweed will germinate and emerge is often difficult. Horseweed, in some regions, may germinate in the fall and behave as a winter annual or may germinate in the spring and behave as a summer annual. It is important to investigate both genetic and environmental factors that allow for horseweed germination and emergence. A common garden field study was conducted with an objective to determine the germination and emergence timing of eight different horseweed populations. Horseweed seeds were collected from 30 plants in each of two locations across the four states, from KY, IL, MO, and KS. At least 200 viable seeds of the eight populations were sown into individual rings at the Department of Agronomy Research Field near Manhattan, KS on November 10, 2016, and on October 10, 2017. The experimental design was a randomized complete block with six replications and eight populations. Emergence counts were taken on a weekly basis during fall and spring months and on a monthly basis during winter months. Once cotyledons were visible, plants were pulled and horseweed number was recorded. Data were analyzed in SAS using an LSD of 0.05 to test for differences in emergence across sampling dates and emergence differences between populations. In year one, there were no differences among numbers of emerged plants across populations; however, for populations emergence was greater on one sampling date. Ninety percent of the 200 viable seeds emerged by April 14,

2017. Similarly, in year two, there were no differences among numbers of total emerged plants across populations for each sampling date; however, emergence was greater on one sampling date across populations. Only 30% of 200 seeds emerged by October 16, 2017, but was greater than 95% of the total emergence across populations. This suggests that horseweed seed from geographically different locations will emerge when environmental conditions are favorable, rather than specific seasons.

COMPARISON OF FALL AND SPRING BURNDOWN PROGRAMS FOR MANAGING GLYPHOSATE RESISTANT HORSEWEED IN SOYBEANS. Kaity Wilmes*, Christopher Proctor, Amit Jhala; University of Nebraska-Lincoln, Lincoln, NE (82)

Managing glyphosate-resistant horseweed (*Conyza canadensis* (L.) *Cronquist*) is a growing challenge for row-crop producers. Horseweed is a prolific seed producer with a large germination window that can range from late summer to spring. In central and eastern Nebraska, horseweed primarily emerges in the fall, which may result in plants that are too large to effectively control with a spring herbicide application. In addition, unfavorable and unpredictable spraying conditions in the spring can lead to poor application timing, thus affecting the efficacy of spring herbicide applications. The objectives of this study were to 1) evaluate the efficacy of fall and spring herbicide applications on the control of glyphosate-resistant horseweed and 2) measure the effect of different herbicide programs for controlling horseweed on soybean (*Glycine max* L.) yield. This study was conducted over two years (2016/2017, 2017/2018) under dryland conditions at the Havelock research farm near Lincoln, Nebraska. Herbicide treatments were various combinations of fall or spring burndown treatments followed by preemergence (PRE) and postemergence (POST) applications. Data were collected on visual estimation of control, biomass of horseweed, and soybean grain yield. Early spring evaluation showed fall burndown treatments provided 90% or greater control of horseweed. By mid-season, for identical PRE/POST programs there was no difference in control of horseweed between fall and spring burndown treatments. Similarly, these PRE/POST programs showed no difference between fall and spring burndown treatments on soybean yield. PRE treatments resulted in lower horseweed biomass and greater soybean yield than the POST only treatment. Results confirm the importance of timely control of horseweed to avoid yield loss in soybeans. While there was no yield advantage to fall burndown treatments compared with spring burndown treatments, there was also no yield penalty. In some situations, it may benefit growers to use a fall burndown treatment to spread out the timing of field operations.

THE INTERACTION OF PLANT CUTTING AND HERBICIDE APPLICATION ON HORSEWEED CONTROL. Colton P. Carmody*[1], Ron Krausz[2], Karla L. Gage[1]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (83)

Double-cropping winter wheat (*Triticum aestivum* L.) and soybeans (*Glycine max* (Merr) L.) may allow producers in southern Illinois to harvest two crops from the same field in a given year. The no-till practices typically associated with double-crop soybeans may cause an increase in populations of small-seeded broadleaf weeds such as horseweed (*Conyza canadensis* (L.) *Cronq.*), which germinate from shallow soil depths. Horseweed in the US has evolved resistances to ALS-inhibitors, EPSP synthase-inhibitors, PSI electron diverters, and PSII-inhibitors; and long-distance wind dispersal of horseweed creates management challenges impacting large geographies. Properly stewarded glufosinate- or dicamba-resistant soybean systems may be reliable methods for controlling herbicide-resistant horseweed populations. Efficacy of these available technologies must be preserved. In a double-crop system, horseweed plants may reach diameters of 7.5 cm or greater and bolting stage by the time of wheat harvest. In order to improve stewardship of glufosinate- and dicamba-resistant soybean technologies following a winter wheat crop, a two-year field study was established in Carbondale, Illinois, at a location with > 70% frequency of glyphosate-resistant horseweed. The objective of the study was to evaluate the effects of cutting height, herbicide applications, and timing of herbicide application on the control of horseweed and other weeds. Plots were 3 m by 9 m, and were divided into 3 m subplots to test the effect of cutting height. Cutting treatments were: uncut, 15-cm cutting height, and 30-cm cutting height. Herbicide applications were: nontreated; dicamba + glyphosate (1683 g ai ha^{-1}) + saflufenacil (25 g ai ha^{-1}); dicamba + glyphosate (1683 g ai ha^{-1}) + metribuzin (421 g ai ha^{-1}); dicamba + glyphosate (1683 g ai ha^{-1}) + flumioxazin (74 g ai ha^{-1}) + chlorimuron (25 g ai ha^{-1}); dicamba + glyphosate (1683 g ai ha^{-1}) + sulfentrazone + cloransulam (314 g ai ha^{-1}), dicamba + glyphosate (1683 g ai ha^{-1}); glyphosate (1268 g ai ha^{-1}); paraquat (1122 g ai ha^{-1}); glufosinate (656 g ai ha^{-1}); and dicamba (561 g ai ha^{-1}). Herbicide application timings were: immediately after cutting or seven days after cutting. Weed control rating were taken at 7, 14, 21, and 35 days after treatment (DAT) for horseweed, Canada goldenrod (*Solidago canadensis* L.), and common ragweed (*Ambrosia atrimesifolia* L.) in 2017 and horseweed only in 2018. Additionally, three horseweed plants from each subplot were tagged and monitored throughout the study, and above- and below-ground biomass was collected. Data were analyzed using a three-way ANOVA to observe the effects of cutting height, herbicide treatment, and application timing on visual estimations of weed control and biomass. Results suggest that 15-cm cutting height combined with the specific herbicides used in this study provided greater weed control over the 30-cm cutting height and uncut plants in both 2017 and 2018 for herbicide treatments, while application timing did not have an effect on horseweed plants at 35 DAT. Common ragweed control was the only weed species with greater weed control based on application timing. Weed control in common ragweed was greater when herbicide applications were applied immediately after cutting at 35 DAT. The effect of cutting height on the perennial, rhizomatous species, Canada goldenrod, was different from horseweed, in that cutting at 15-cm height resulted in lower control efficacy than cutting at 30 cm or uncut treatments. Finally, it was observed that all treatments, except glyphosate alone, provided > 80% control of horseweed at 35 DAT, but contact herbicides allowed for plant regrowth to occur after 35 DAT. In conclusion, mechanical cutting of weeds to 15-cm height during winter wheat harvest may increase control efficacy of herbicide treatments on large annual weeds, and therefore, may be a component of stewardship of soybean technologies in a wheat double-crop system.

EFFICACY OF POST APPLIED DICAMBA AT DIFFERENT TIMINGS IN RR2XTEND SOYBEAN SYSTEMS IN WISCONSIN. Sarah Striegel*[1], Ryan P. DeWerff[2], David E. Stoltenberg[1], Rodrigo Werle[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]Agricultural Research of Wisconsin, LLC, Madison, WI (85)

Soybeans are an important crop species worldwide and are commonly grown in cropping systems in Wisconsin. Many factors can negatively impact soybean yield and seed quality, including the competition from weeds and weed seedbank deposits. Innovative management is becoming more important as the number of resistant weed populations continue to increase. Roundup Ready 2 Xtend (glyphosate- and dicamba-tolerant) is a novel option for control of herbicide-resistant broadleaf weeds postemergence (POST) in soybeans. Utilizing dicamba in a multi-year rotational program can offer ease of in-season weed control. A field study was conducted in 2018 at three locations in Wisconsin to determine the efficacy of glyphosate + dicamba applied POST in RR2Xtend soybeans at different timings: V2, V4, and R1. The addition of acetochlor as part of the glyphosate + dicamba POST treatment and its impact on overall weed control was also evaluated. Herein we focus on the results obtained at the Janesville location, where *Ambrosia trifida* was the target species. A treatment receiving only flumioxazin applied pre-emergence (PRE) resulted in 67% control of *A. trifida* at Janesville at the end of the season. Satisfactory weed control (>90%) was achieved for PRE (flumioxazin) followed by POST treatments, regardless of POST application timing. The addition of acetochlor in combination with glyphosate + dicamba did not enhance *A. trifida* control when compared to glyphosate + dicamba. Emergence patterns of prevalent weed species were evaluated during the season to aid in determination of optimal POST application timing. Crop yield data were collected. The findings of this study, which will be replicated during the 2019 growing season, will help producers decide when the best time to complete a POST application is, the value for additional layered residual herbicide, the risks and benefits associated with the respective timing, and how the use of RR2Xtend technology can help to diversify their weed management programs.

EFFECTS OF TILLAGE AND FERTILITY ON THE WEED SEEDBANK OVER 49 YEARS IN SOUTHERN ILLINOIS. Sarah J. Dintelmann*[1], Ron Krausz[2], Karla L. Gage[1]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (86)

Reduced- and no-tillage soil conservation practices provide many benefits, including decreased soil erosion and increased water infiltration and soil organic matter. Tillage practices may also cause weed species shifts over time, but there are relatively few long-term studies on the impacts of reduced- and no-tillage on weed communities. A long-term study was established in 1970 to examine the interactive effects of tillage (conventional, chisel, alternate, and no-tillage) and fertility (No fertilizer, N-only, and NPK) treatments on grain yield and soil characteristics in St. Clair County, Illinois, at the Belleville Research Center. This study also provides the opportunity to test for differences in weed communities as a result of treatment over this 49-year period. Each tillage and fertility treatment combination was replicated four times in the field study in 6 m by 8 m plots. In order to assess the belowground weed community assemblage present in the seedbank, 50 5-cm diameter soil cores were taken $plot^{-1}$ to a depth of 20 cm and combined into a composite sample by plot. Using these soil samples, a seedbank grow-out was conducted in the greenhouse. Each composite sample (plot) was replicated two times in the grow-out. Previously established grow-out methodology was followed. Three runs of the seedbank grow-out were implemented, with soil mixing between each run and cold stratification between runs two and three. Emerged weeds were identified and removed at the seedling stage. There were 14 total weed species present in the seedbank. Emerged weeds were summed across run and averaged by replicate to determine the community composition of each plot. Species community data were analyzed using Non-metric Multidimensional Scaling Ordination (NMDS) and Analysis of Similarity (ANOSIM). Effects of tillage and fertility treatments on species-associated variables of richness, evenness, and Shannon-Weiner diversity index were analyzed using a two-way Analysis of Variance (ANOVA). NMDS revealed distinct clusters of communities by tillage and fertility treatments. When these were compared using ANOSIM, results suggested that the community assemblage of the conventional-tillage with NPK treatment was different from other treatments except alternate-tillage with N-only and chisel-tillage with N-only. The no-tillage, NPK treatment was different from other treatments except alternate-tillage with N-only and the no-tillage, no fertilizer treatment. The conventional-tillage, N-only treatment was different from alternate-tillage with NPK, no-tillage with no fertilizer, and no-tillage with NPK. The conventional-tillage treatment with no fertilizer was different from the alternate-tillage treatment with NPK and no-tillage with NPK. Species richness was greatest in chisel-tillage systems, although not different than conventional-tillage. The no-tillage treatment had the lowest diversity of weeds in the soil seedbank, although this was not different than alternate-tillage. When individual species abundances were analyzed using ANOVA, there were two species affected by tillage or fertility treatments: henbit (*Lamium amplexicaule* L.) and common chickweed (*Stellaria media* (L.) Vill.). Henbit was most abundant in no-tillage and alternate-tillage treatments, and henbit abundance in no-tillage was greater than in chisel- and conventional-tillage treatments with greater levels of disturbance. Fertility influenced the emergence of henbit and common chickweed, both with their highest emergence in high fertility systems (NPK). These results suggest that long-term no-tillage systems can be associated with a depletion of the soil seedbank within the soil profile, which may provide additional value to the benefits of no-tillage as a soil conservation practice.

EFFECTS OF HERBICIDE MANAGEMENT PRACTICES ON THE DENSITY AND RICHNESS OF THE SOIL SEEDBANK IN DICAMBA AND 2,4-D RESISTANT CROPPING SYSTEMS IN INDIANA. Connor L. Hodgskiss*[1], Travis R. Legleiter[2], William G. Johnson[1]; [1]Purdue University, West Lafayette, IN, [2]University of Kentucky, Princeton, KY (87)

The development of herbicide resistant weed populations, has led the agrochemical industry to develop soybean varieties resistant to either 2,4-D choline or dicamba. Therefore the use of 2,4-D and dicamba by producers will increase in coming years. The repetitive use of 2,4-D and dicamba in soybean production systems may lead to shifts in weed species that are more tolerant to auxin herbicides if other modes of action are not incorporated into management practices. Field experiments were conducted to observe weed species shifts in the soil seedbank that occur in 2,4-D and dicamba resistant soybeans as additional modes of action are integrated at varying levels. The research presented was conducted at the Throckmorton Purdue Agricultural Center (TPAC) in Tippecanoe County, Indiana during six consecutive years within a corn-soybean rotation. The different mode of action integration levels were integrated glyphosate with six sites of action (atrazine, S-metolachlor, mesotrione, glyphosate, topramazone, chlormurion, flumioxazin, pyroxasulfone, and fomesafen), auxin reliant with 3 sites of action (atrazine, glyphosate, and 2,4-D or dicamba), integrated auxin with 7 sites of action (atrazine, S-metolachlor, mesotrione, glyphosate, topramazone, chlormurion, flumioxazin, pyroxasulfone, and 2,4-D or dicamba), and fully integrated with 8 sites of action (atrazine, S-metolachlor, mesotrione, glyphosate, topramazone, chlormurion, flumioxazin, pyroxasulfone, glusoinate, and 2,4-D or dicamba). Poaceae density was significantly higher within the dicamba and 2,4-D treatments having 41.78 plants 3000 cm^{-3} and 108.4 plants 3000 cm^{-3} respectively followed by the integrated glyphosate treatment with 13.8 plants 3000 cm^{-3}. In the 6th year of this experiment Poaceae species accounted for 95.6% and 98.8% of the total density in the dicamba and 2,4-D auxin reliant plots respectively, with densities that were at least 142 plants 3000 cm^{-3} higher than all other treatments. Auxin reliant treatments' species number was more influenced by Poaceae species in 2018 than by dicot species as Poaceae species accounted for more than

68% of the total species present. This research suggest relying on 2,4-D and dicamba soybean cropping systems will select for auxin tolerant Poaceae species, which will become prevalent in the soil seedbank by the 6th year. Therefore, producers should continue to implement multiple modes of action to slow weed shifts into other problematic weed species.

EVALUATION OF CEREAL RYE AND CANOLA TERMINATION TIMING ON HORSEWEED AND GIANT RAGWEED CONTROL. Stephanie DeSimini*, William G. Johnson; Purdue University, West Lafayette, IN (88)

Cover crops have received increased attention in recent years due to government cost shares promoting the benefits of cover crops, pushing growers to turn to alternative methods for boosting yield while also protecting their soil. The addition of a cover crop in an existing crop rotation may suppress weeds through competition for resources, or by physical suppression. The objectives of this study were (1) to determine if cover crops reduce horseweed (*Erigeron canadensis*) or giant ragweed (*Ambrosia trifida*) in corn and soybean production and (2) investigate the influence of cover crop termination timings on crop yield. Cereal rye (*Secale cereale*) and canola (*Brassica napus*) were selected for use in this study for their rapidly accumulating aboveground biomass, potential allelopathy, and winter hardiness. Field experiments were initiated in 2016 and repeated in 2017 at the Throckmorton Purdue Agricultural Center (TPAC) near West Lafayette, IN and the Southeast Purdue Agricultural Center (SEPAC) near Butlerville, IN. SEPAC was selected for its horseweed populations, while TPAC was selected for its giant ragweed populations. Herbicide treatments were applied the following spring around our crop planting dates. Early cover crop termination was two wks before planting (WBP) our desired cash crop, and late termination was two wks after planting (WAP). Corn and soybeans were planted in early May in both 2017 and 2018. Horseweed and giant ragweed densities and total weed biomass samples were collected at each termination timing. Corn and soybeans were harvested at the end of October in 2017 and 2018. There were no differences in horseweed or giant ragweed densities in any cover crop treatment. There was a reduction of horseweed biomass in both cereal rye and canola plots compared to the fallow treatment. Cereal rye reduced weed biomass by 66% terminated 2WBP compared to fallow treatments. Canola reduced weed biomass by 68% terminated 2WBP compared to fallow treatments. In giant ragweed, there was a reduction of biomass in both cereal rye timings and at the late canola termination timing. Cereal rye treatments reduced weed biomass by 56% terminated 2WBP compared to fallow treatments. Canola reduced weed biomass by 40% terminated 2WAP compared to fallow treatments. There were no differences in soybean yield at TPAC in 2018 between any cover crop treatment. However, there was a 35% reduction in corn yield following cereal rye terminated 2WBP and a 48% yield reduction following cereal rye terminated 2WAP compared to the fallow treatments. Horseweed and giant ragweed densities were not different in cover crop treatments, but total weed biomass was lower in cover crop treatments compared to fallow treatments. The reduction of weed biomass could expand the timeline growers have to spray target weeds sized 5-10 cm. These results suggest that cover crops can be an effective addition to conventional cropping systems if cereal rye is not used prior to corn and selected herbicide programs include an early termination prior to corn and soybean planting.

IMPACT OF HERBICIDE PROGRAMS TARGETING PIGWEED SPECIES ON GRASSES AND LARGE SEEDED BROADLEAVES. Allen J. Scott*[1], Reid Smeda[1], Aaron Hager[2], Jason K. Norsworthy[3], Bryan G. Young[4]; [1]University of Missouri, Columbia, MO, [2]University of Illinois, Urbana, IL, [3]University of Arkansas, Fayetteville, AR, [4]Purdue University, West Lafayette, IN (89)

Grower reliance on glyphosate in soybeans has resulted in widespread selection of resistant waterhemp (*Amaranthus rudis*) and Palmer amaranth (*Amaranthus palmeri*) across the Midwest and Mid-south. Greater adoption of residual herbicides increases the control of Amaranthus spp., but the effectiveness on grasses and large-seeded broadleaves is not documented. Field research at multiple locations (IL, IN, MO, AR) over multiple years and different locations each year compared postemergence (POST) only to various pre-emergence (PRE) and POST programs for management of Amaranthus, as well as other species. Weed density at the time of a POST application as well as at soybean harvest was compared to an untreated control. With variable species across locations and years, weed density was grouped as Amaranthus, grasses and large-seeded broadleaves. Except for S-metolachlor in IN in 2016 and 2017, and metribuzin + chlorimuron in IL and MO in 2017, treatments containing residual herbicides reduced grass populations up to 100%. The efficacy of residual herbicides on large-seeded species was dependent on both the specific active ingredient and species. In general, S-metolachlor was weakest for suppression of large-seeded broadleaves and mixtures containing metribuzin as well as pyroxasulfone were most effective. Numerous large-seeded broadleaves were present at the early POST timing. Addition of dicamba to fomesafen reduced the density of large-seeded species from 38 to 100% greater versus fomesafen alone at six of seven site years. At harvest, weeds reduced yields in untreated plots by an average of 58 to 69% across years and locations versus the highest yielding treatment. Growers have many effective chemical programs on annual grasses in soybeans. Targeted control of large-seeded broadleaves requires selective PRE and POST options to preclude increasing soil seed bank populations.

EFFECT OF ADJUVANTS ON PHYSICAL PROPERTIES OF GLYPHOSATE AND PPO-INHIBITING HERBICIDE SPRAY MIXTURES.
Jesaelen Gizotti de Moraes*[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (90)

Adjuvants are known to enhance spray droplet retention on leaf surface and penetration of herbicide active ingredient through cuticle due to changes in physical properties such as density, viscosity, surface tension (SFT), and contact angle (CA) increasing leaf wettability. Previous research has shown that the performance of an adjuvant is dependent on the herbicide with which it is applied, the plant species, and environmental conditions. The objectives of this study were to determine the effect of adjuvants on these physical properties when glyphosate and lactofen are applied alone and in combination and to determine if these changes can be correlated to herbicide efficacy. The study was conducted at the Pesticide Application Technology (PAT) Laboratory located at the West Central Research and Extension Center in North Platte, NE. Treatments consisted of 10 spray solutions using a carrier volume of 187 L ha^{-1} of glyphosate at 630 g ae ha^{-1}, or lactofen at 110 g ai ha^{-1} alone, lactofen at 110 g ai ha^{-1} with the adjuvants crop oil concentrate (COC) at 1% v v^{-1}, non-ionic surfactant (NIS) at 0.25% v v^{-1}, methylated seed oil (MSO) at 1% v v^{-1}, or drift retardant agent (DRA) at 0.5% v v^{-1}, and herbicides in combination with each of the adjuvants aforementioned. Water alone was included for comparison. The static CA was measured on the adaxial leaf surface of five plant species and mylar plastic cards were included as surface sample for comparison. Density, viscosity, SFT, and CA were analyzed separately and subjected to ANOVA and means were separated using Fisher's Protected LSD test and the Tukey adjustment. The impact by the addition of the adjuvants into the treatment solutions was greater on viscosity than on density values. Overall, adjuvants decreased the SFT of treatment solutions when compared to either water or herbicides alone. In addition, reduced CA was observed due to the reduction in SFT. However, results were adjuvant and species-dependent. Herbicide efficacy was only partially explained by the changes in these physical properties. Observations from this study highlighted the importance of adjuvants on reducing SFT and CA properties of spray solutions, but further investigation is needed to better understand the factors influencing herbicide uptake and how they are correlated in order to maximize herbicide efficacy.

PHYSICAL PROPERTIES OF VARIOUS GLYPHOSATE FORMULATIONS AS CRITICAL COMPONENTS FOR COMMOM LAMBSQUARTERS (*CHENOPODIUM ALBUM* L.) CONTROL.
Milos Zaric*[1], Jesaelen Gizotti de Moraes[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (91)

Common lambsquarters (*Chenopodium album* L.) belongs to one among most troublesome weed species through the United States. Characteristics that is consistent with all species from Chenopodiaceae family is the presence of epicuticular waxes on leaf surface. Leaf surface with waxes like this may play an important role in reduction of wettability and foliar penetration of the most commonly applied post-emergence herbicide such as glyphosate. Considering that difference among standard glyphosate products is mainly due to formulation additional research were needed to examine efficacy on lambsquarters plants. In order to overcome this natural barrier surfactants are often added into solution. Therefore, the objectives of this study was to: (1) 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, and (2) to evaluate relationship between physical properties and weed efficacy when various glyphosate formulations are used. Efficacy study was performed when common lambsquarters plants were 30 cm tall using various glyphosates formulated as potassium and isopropylamine salts at 420 g ae ha^{-1}. The application was performed using a single nozzle track sprayer calibrated to deliver 94 L ha^{-1} using Teejet AI95015EVS nozzle at 414 kPa. Treatment design was consisted of 11 treatments: check, potassium salt (unloaded formulation) with addition of five different rates of NIS (0, 0.125, 0.25, 0.5, and 1% v v^{-1}), two potassium salts (loaded formulation), and three isopropylamine salt (loaded formulation). Visual estimations of injury are recorded up to 28 days after application. Physical properties (density, viscosity, surface tension, and contact angle) for all treatments used from efficacy study were measured using sophisticated equipment at the PAT Lab in North Platte, NE. All data were analyzed using analysis of variance in SAS with mean separation at α=0.05 using Fisher's protected LSD test. Results of this study demonstrates that the addition of NIS to unloaded glyphosate formulation is necessary in order to maximize herbicide efficacy. Furthermore, for unloaded formulation of potassium salt as amount of NIS increase, density and viscosity of tested solutions increase which reduce surface tension and contact angle and results in higher efficacy. However, efficacy related with loaded isopropylamine salt formulation only can be partially explained by looking at physical properties. Considering various herbicide formulations, amount of surfactants used, and surface itself represents critical components for successful common lambsquarters control.

SPRAY DRIFT FROM DICAMBA IN TANK-MIXTURES WITH ADJUVANTS SPRAYED THROUGH FLAT-FAN NOZZLES. Guilherme Sousa Alves*[1], Bruno Canella Vieira[2], Greg R Kruger[1], Joao Paulo R. da Cunha[3]; [1]University of Nebraska, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]Federal University of Uberlandia, Uberlandia, Brazil (92)

Recent introductions of genetically modified cultivars of soybean and cotton which tolerate growth regulator herbicides, including dicamba, allow these compounds to be used with a greater flexibility. However, susceptible crops may be exposed to non-target herbicide drift. The objective of this study was to evaluate the potential reduction on dicamba particle drift in a wind tunnel resulted by adding drift-retardant adjuvants in the tank-mixture sprayed through non-air induction and air induction flat-fan nozzles. A Completely Randomized Design was used in a 5 x 4 x 7 split-split-plot arrangement with four replications. Main-plot, sub-plot, and sub-sub-plot consisted of five spray compositions, four nozzle types, and seven downwind distances from the nozzle, respectively. The solutions were composed of dicamba alone or a combination of dicamba plus one of four different adjuvants (polymer, ammonium sulfate, vegetable oil, and phosphatidylcholine). Solutions were sprayed through XR110015, TT110015, AIXR110015, or TTI110015 nozzles, positioned 0.5 m above the collectors. Each replication consisted of a continuous 10-sec application, at 276 kPa pressure and 3.5 m s-1 wind speed. Round strings were used as drift collectors, positioned at 2, 3, 4, 5, 6, 7, and 12 m downwind from the nozzle. Drift was calculated by quantifying a fluorescent tracer added to the solutions. Dicamba spray drift depended on the interaction between nozzle type and adjuvant. The highest and lowest percentages of drift from dicamba with or without any adjuvant, were generated through XR and TTI nozzles, respectively. The air induction nozzles produced lower drift than non-air induction nozzles across distances and dicamba solutions. The TT and AIXR nozzles produced a similar drift at 12 m, when dicamba was sprayed with polymer. The adjuvants had greater drift reduction at closer distances to the nozzle.

COMPARISON OF AIR SAMPLER FLOW RATE AND FILTRATION MEDIA ON DETECTING OFF-TARGET MOVEMENT OF DICAMBA. Tomas F. Delucchi*, Marcelo Zimmer, Julie Young, Bryan G. Young; Purdue University, West Lafayette, IN (93)

Use of the herbicide dicamba increased rapidly following the commercialization of dicamba-resistant soybean in 2017. The introduction of this new technology to the farming systems raised major concerns since some applications of dicamba that were reported to follow label directions still resulted in off-target movement (OTM) of dicamba to adjacent sensitive plants. The problem with spraying dicamba is not only the movement of physical spray particles during the application process (primary drift) but also the secondary drift that can occur hours or even days after the application. Secondary drift can occur when spray particles stay suspended in the air, potentially from the presence of a temperature inversion during the application. OTM can also occur after dicamba vapor is generated from target surfaces. Finally, dicamba can move attached to soil particles or dust carried in the wind. Further research on dicamba OTM is necessary to build our knowledge base to ultimately guide improved stewardship practices. The objective of this research was to investigate some of the methodology used for field-scale herbicide drift research. More specifically, the research was designed to determine the influence on the flow rate used in air sample pumps and the filtration media used to capture dicamba. Field research was conducted in a field near Chalmers, IN planted with dicamba-resistant soybean. A central portion of the field measuring 61 m x 61 m was sprayed when soybeans reached the R1 growth stage with the combination of dicamba (560 g ae ha^{-1}), glyphosate (1,260 g ae ha^{-1}), and a guar gum drift reduction agent (0.5% v v^{-1}). The application was performed with an ATV sprayer equipped with TTI11003 nozzles at 207 kPa and a carrier volume of 140 L ha^{-1}. Nine air sampling units were deployed at 30 min following the herbicide application to allow the spray droplets to settle. These air samplers were positioned with one on each side, at each of the four corners and one in the middle of the treated area. These units were equipped with a 10-cm diameter ultrapure glass fiber filter paper in series in front of a 7.5-cm long by 6-cm wide polyurethane foam (PUF) vapor collection substrate and calibrated for a flow rate of three L min^{-1}. Two additional air samplers were positioned in the downwind direction from the application area (North and East) and calibrated for a higher flow rate of 4.5 L min^{-1}. Lastly, two more air samplers were also positioned in the North and East locations with a flow rate of three L min^{-1} but equipped with a cassette style filter. Filters in the air sampling units were started 0.5 hours after application and then collected/replaced at 6, 18, 30 and 42 hr after herbicide application. The PUF and cassette samples were sent to the Mississippi State Chemical Laboratory for dicamba analysis. Results from dicamba analysis are still pending. Dicamba quantification was variable across both air flow rates and filter media types. Thus, no major conclusions on the differences between these critical dicamba air sampling parameters can be drawn from our research at this time.

IMPACT OF CARRIER VOLUME RATE ON PRE-EMERGENCE HERBICIDE EFFICACY IN WISCONSIN CROPPING SYSTEMS. Rachel Renz*[1], Sarah Striegel[2], Ryan P. DeWerff[3], Nikola Arsenijevic[4], Victor Hugo V. Ribeiro[2], Maxwel Coura Oliveira[2], Brian Luck[2], Rodrigo Werle[2]; [1]University of Wisconsin-River Falls, River Falls, WI, [2]University of Wisconsin-Madison, Madison, WI, [3]Agricultural Research of Wisconsin, LLC, Madison, WI, [4]University of Nebraska Lincoln, North Platte, NE (95)

In the US north-central region, the use of pre-emergence (PRE) herbicides is becoming a standard practice for weed control in corn and soybeans. Environmental conditions often challenge farmers with timely PRE herbicide applications in the upper Midwest (e.g., planting often takes priority over spraying when conditions are adequate in the spring). Combining planting and spraying into a single operation could mitigate challenges and enable growers to early-plant and spray. In 2018, field studies were conducted at Arlington (predominance of grass weeds) and Janesville (predominance of giant ragweed), Wisconsin to evaluate the impact of carrier volume rate and PRE-emergence herbicide selection on weed control in corn and soybeans. The studies consisted of three herbicide products applied at their recommended field rate (corn study = Resicore [4.1 L ha^{-1}], Acuron Flexi [5.3 L ha^{-1}] and Anthem Maxx [0.3 L ha^{-1}]; soybean study = Canopy DF [158 g ha^{-1}), Fierce [280 g ha^{-1}] and Verdict [0.36 L ha^{-1}]) sprayed at five carrier volume rates (23, 47, 94, 140 and 164 L ha^{-1}) replicated four times and organized in a RCBD. An untreated control treatment was included for each study. The crops were planted following PRE-plant tillage (common strategy in Wisconsin). Herbicide treatments were sprayed after planting with a Gator operated at 8 kph and nozzles spaced at 76 cm (simulating planting conditions). Different combinations of nozzle and spray pressure were used to achieve the different carrier rate volumes tested herein. Visual estimation of control and biomass reduction were recorded at 40 DAT. 2018 results show that carrier volume did not influence weed control nor weed biomass reduction in both the corn and soybean studies at both locations ($P>0.05$). In corn, Acuron Flexi and Resicore provided excellent weed control (>90%), while Anthem Maxx resulted in less than 65% weed control across locations at 40 DAT. In general, higher weed control (averaged across herbicides) was achieved in Janesville (94%) than Arlington (80%) in the corn study. In soybeans, weed control across herbicide treatments was higher in Arlington than Janesville. Fierce, Verdict and Canopy provided 92%, 84% and 74% weed control in Arlington, respectively. Soybean herbicides tested herein provided less than 60% weed control in Janesville at 40 DAT. Herbicide selection, crop canopy and weed spectrum were likely the main factors influencing weed control in Arlington and Janesville. These preliminary results indicate that efficacy of PRE corn and soybean herbicides sprayed after a pre-plant tillage operation was not influenced by carrier volume rate. Although further research is needed to validate our findings, reduction in carryover volume for delivery of PRE herbicides could enable farmers to couple planting and spraying into a single operation (assuming product labels allow that).

INFLUENCE OF SPRAY NOZZLE AND BOOM HEIGHT ON HERBICIDE DRIFT. Catlin M. Young*[1], Travis R. Legleiter[2]; [1]Murray State University, Princeton, KY, [2]University of Kentucky, Princeton, KY (96)

A trial was conducted in the summer of 2018 at the University of Kentucky Research and Education

Center at Princeton to examine the influence of spray boom height and nozzle types on drift as well as coverage and deposition. Nozzles evaluated were: XR11004, ULD12004, and TTI11004. Each nozzle was evaluated at three heights which included: 61 cm, 122 cm, and 122 cm with 61 cm drops. A 14 m long by 1.5 m wide spray swath of dicamba plus glyphosate was applied using an ATV at 14.5 kph with a pressure of 345 kPa for an output of 140 L ha^{-1}. Kromekote spray cards were placed within the spray swath for analysis of coverage and deposition and downwind from the spray swath in two transects from 1.5 m to 61 m for analysis of drift distance. The nozzle that had the greatest drift detection was the XR nozzle at boom height of 122 cm which resulted in drift to maximum range evaluated at 61 m and was greater than other nozzle and height combinations. These results reinforce that using the correct nozzles such as the ULD or TTI when spraying dicamba will reduce your drift potential when following all other label restriction. This data also reinforces the importance of applying with the correct boom height of 61 cm above the target to reduce drift potential. Any differences in coverage were influenced by nozzle type and not boom height revealing the potential to use drops to effectively lower boom height.

INTERFERENCE OF CLETHODIM ON GLYPHOSATE FOR BROADLEAF WEED CONTROL AS AFFECTED BY SURFACTANT ADJUVANTS. Sofija Petrovic*[1], Isidor Ceperkovic[2], Kasey Schroeder[1], Jeffrey Golus[1], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Univeristy of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska, North Platte, NE (97)

Glyphosate is a non-selective herbicide and is often applied in tank-mixtures with clethodim to maximize control of grass species including glyphosate-tolerant volunteer corn. Herbicides applied in combination is a common practice to maximize control and slow the evolution of resistance. However, tank-mixture interactions (synergism or antagonism) may occur which can affect weed control. Therefore, the objective of this research was to determine the type of interaction on grass weed control when clethodim and glyphosate (without surfactant) are applied in tank-mixtures with selected surfactants. The study was arranged as a Completely Randomized Design with five replications and two independent experimental runs. The weed species were velvetleaf (*Abutilon theophrasti*) and common lambsquarters (*Chenopodium album*). Spray treatments consisted of postemergence applications using glyphosate (without any surfactant in its formulation) at 630 g ae ha-1 and clethodim at 51 g ai ha^{-1} alone or combined with each other and with one of seven surfactants; and glyphosate (with surfactant in its formulation) alone and in combination with clethodim at those rates previously described. Applications were performed using a three-nozzle Research Track Sprayer with AIXR11004 nozzles, delivering 93 L ha^{-1} at 276 kPa at 5.3 m s^{-1}. Plants were evaluated at 7, 14, 21 and 28 days after treatment (DAT), clipped at soil surface at 28 DAT and placed in a dryer for 72 hr. Dry biomass was recorded and converted into percent biomass reduction. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test and the Tukey adjustment. There was synergistic interactions on control of common lambsquarters when selected surfactants were added to glyphosate and glyphosate + clethodim tank-mixtures. When surfactants were added to clethodim alone, it did not improve or reduce control of common lambsquarters. There was an antagonistic interaction on control of velvetleaf when some surfactants were added to clethodim and glyphosate.

GRASS WEED CONTROL FROM GYPHOSATE AND CLETHODIM APPLICATIONS AS AFFECTED BY SURFACTANTS. Isidor Ceperkovic*[1], Sofija Petrovic[2], Jeffrey Golus[2], Kasey Schroeder[2], Greg R Kruger[3]; [1]Univeristy of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska, North Platte, NE (98)

Clethodim is an ACCase-inhibiting herbicide extensively used in soybeans as a postemergence option to control annual and perennial grass species including volunteer corn. This herbicide is often applied to glyphosate-tolerant soybeans in tank-mixtures with glyphosate to broaden spectrum of weed control. Modified activity (synergism or antagonism) of one or more of the tank-mixture herbicides may be observed due to chemical interactions. Surfactant and oil adjuvants may enhance herbicide performance by providing better coverage and in some cases can help overcome antagonism of herbicides. Therefore, the objective of this research was to determine the type of interaction on grass weed control when clethodim and glyphosate are applied alone or in tank-mixtures with surfactants. A greenhouse study was conducted at the Pesticide Application Technology (PAT) Laboratory located at the West Central and Extension Center in North Platte, NE, on the following grass species: corn (*Zea mays* L.), oat (*Avena sativa* L.), and annual ryegrass (*Lolium multiflorum* Lam.). The study was arranged as a Completely Randomized Design with five replications and two independent experimental runs. Spray treatments consisted of postemergence applications using glyphosate (without any surfactant in its formulation) at 630 g ae ha^{-1} and clethodim at 51 g ai ha^{-1} alone or in combination with one of seven surfactants; and glyphosate (with surfactant in its formulation) alone and in combination with clethodim for comparison. All applications were performed using a three-nozzle Research Track Sprayer with AIXR11004 nozzles, delivering 93 L ha^{-1} at 276 kPa at 5.3 m s^{-1} (19 kph). Plants were evaluated at 7, 14, 21 and 28 days after treatment (DAT), clipped at soil surface at 28 DAT and placed in a dryer for 72 hr. Dry biomass was recorded and converted into percent biomass reduction. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test and the Tukey adjustment.

INTERFERENCE OF CLETHODIM ON GLYPHOSATE FOR BROADLEAF WEED CONTROL AS AFFECTED BY OIL BASED ADJUVANTS. Thais Uany de Souza*[1], Camila Chiaranda Rodrigues[1], Kasey Schroeder[1], Jeffrey Golus[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (99)

Glyphosate is the most widely used non-selective herbicide worldwide and the use increased after the introduction of glyphosate-tolerant crops in 1996. The ACCase-inhibiting herbicides such as clethodim are frequently used in tank-mixtures with glyphosate to control glyphosate-resistant volunteer corn. Antagonistic interactions may occur when two or more products are applied in tank-mixtures. The objective of this study was to evaluate the broadleaf weed control using glyphosate and clethodim when using different adjuvants in the solution. Greenhouse experiments were conducted at the Pesticide Application Technology (PAT) Laboratory located at the West Central Research and Extension Center in North Platte, NE, using four weed species: horseweed (*Conyza canadensis* L.), kochia (*Kochia scoparia* (L.) Schrad.), common lambsquarters (*Chenopodium album* L.), and velvetleaf (*Abutilon theophrasti* Medik). The study was arranged as a Completely Randomized Design with five replications in each of two independent experimental runs. Spray treatments consisted of postemergence applications using glyphosate at 630 g ae ha^{-1} and clethodim at 51 g ai ha^{-1} alone and in combination with each other and with 14 oil-based adjuvants (methylated seed, paraffinic, and soybean oils) at different concentrations. Applications were performed using a three-nozzle Research Track Sprayer with AIXR11004 nozzles, delivering 93 L ha^{-1} at 276 kPa at 5.3 m s^{-1}. Plants were evaluated at 7, 14, 21 and 28 days after treatment (DAT), clipped at soil surface at 28 DAT and placed in a dryer for 72 hr. Dry biomass was recorded and converted into percent biomass reduction. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test and the Tukey adjustment. Oil based adjuvants caused a greater impact on weed control when applied in tank-mixture with glyphosate compared to clethodim because caused less activity of glyphosate and antagonistic interactions could be observed in specific treatments. Results were adjuvant- and weed species-specific.When applied in tank-mixture with glyphosate plus clethodim to velvetleaf and commom lambsquarters antagonistic interactions were observed 100% of the time, except for a single treatment applied to velvetleaf. Oil can cause antagonism, especially when applied in combination with glyphosate.

INFLUENCE OF TANK CLEANOUT PRODUCTS AND PRACTICES TO REMOVE DICAMBA FROM COMMERCIAL SPRAY EQUIPMENT.". David J. Palecek*[1], Ryan J. Edwards[2], Gregory K. Dahl[1], Joshua Skelton[3], Dustyn Sawall[4], Laura Hennemann[2], Andrea Clark[5], Lee A. Boles[1]; [1]Winfield United, River Falls, WI, [2]Winfield Solutions, River Falls, WI, [3]WinField United, River Falls, WI, [4]Ag Precision Formulators, Middleton, WI, [5]Winfield Solutions, LLC, River Falls, WI (100)

Best Management Practices for the new dicamba technology depend on starting and ending each day with a clean sprayer. Often dicamba spray injury to soybeans is due to improper tank and equipment clean out. The purpose of this study was to compare biological and analytical test methods and capabilities to detect the presence of dicamba during tank clean out using a commercial sprayer. Water alone and several commercial tank cleaners were compared. The tank and rinsate samples were obtained while cleaning a John Deere R4023 sprayer. This study used biological measurements along with visual ratings to determine the effectiveness of each treatment. The samples were also analyzed with High Performance Liquid Chromatography (HPLC) testing conducted in our chemistry lab. The results from the HPLC was used to quantify the amount of dicamba present throughout the various rinse stages and sites. Dicamba was detected at levels that caused injury symptomology, even after triple rinsing of the sprayer. The HPLC was able to detect very low levels of the dicamba even after triple rinsing.

GRASS WEED CONTROL FROM GYPHOSATE AND CLETHODIM APPLICATIONS AS

AFFECTED BY OIL BASED ADJUVANTS. Camila Chiaranda Rodrigues*[1], Thais Uany de Souza[1], Jeffrey Golus[1], Kasey Schroeder[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (101)

Herbicides and adjuvants applied in tank-mixtures are a common approach used by farmers in the field. Usually, this practice is used to enhance spray applications and maximize weed control. Caution is needed when tank-mixing pesticides due to the potential for incompatibility of products. Therefore, the objective of this study was to determine the impact of different oil-based adjuvant formulations on grass control using glyphosate and clethodim applied alone and in tank-mixtures. The species were non-tolerant glyphosate corn (*Zea mays* L.), oat (*Avena sativa* L.), and ryegrass (*Lolium perenne*L. ssp. multiflorum (Lam.) Husnot). The study was arranged as a Completely Randomized Design with five replications and two independent experimental runs. Spray treatments consisted of postemergence applications using glyphosate at 630 g ae ha^{-1} and clethodim at 51 g ai ha^{-1} alone and combined with each other and with 14 oil-based adjuvants (methylated seed, paraffinic, and soybean oils) at different concentrations. Applications were performed using a three-nozzle Research Track Sprayer with AIXR11004 nozzles, delivering 93 L ha^{-1} at 276 kPa at 5.3 m s^{-1}. Visual estimations of injury were collected at 7, 14, 21, and 28 days after treatment (DAT), clipped at soil surface at 28 DAT and placed in a dryer for 72 hr. Dry biomass was recorded and converted into percent biomass reduction. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test and the Tukey adjustment. Oil-based adjuvants did not affect the activity of clethodim but less glyphosate activity was observed mainly with increased adjuvant concentration. Similar plant structure (oats and ryegrass) showed similar antagonistic treatments. Overall, greater antagonism effect was observed with the MSO formulation.

SPRAY DRIFT FROM MESOTRIONE AND ISOXAFLUTOLE THROUGH DIFFERENT NOZZLE TYPES. Andrea Rilakovic*[1], Guilherme Sousa Alves[2], Bruno Canella Vieira[3], Thalyson Medeiros de Santana[1], Rosa Soriano[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE, [3]University of Nebraska, Lincoln, NE (102)

The HPPD-inhibitor-tolerant crops, such as cotton and soybean, will reach the US market in the next few years. HPPD-inhibiting herbicides have the potential to damage on non-tolerant crops. The objective of this study was to investigate spray drift effects on sensitive crops during post applications of mesotrione and isoxaflutole through three nozzle designs in a wind tunnel. The experiment was conducted in a Completely Randomized Design with five replications within each nozzle type tested. Herbicide, crop, and distance were considered as main-plot, sub-plot, and sub-sub-plot, respectively. The nozzles used were XR110015, AIXR110015, and TTI110015, operated at 276 kPa and positioned 40 cm above the canopy. The herbicides used were mesotrione and isoxaflutole at rate of 88 g ha^{-1}. The solution was prepared simulating an application at 93.4 L ha^{-1}. Drift was estimated by adding to the solution a fluorescent tracer (PTSA) at 2 g L^{-1} and quantified afterwards by fluorimetry using mylar cards. Crops (cotton (*Gossypium hirsutum* L.), soybean (*Glycine max* (L.) Merr.), oat (*Avena sativa* L.), and sorghum (*Sorghum bicolor* L.)) were treated when they were 15 cm tall. In a wind tunnel, the plants and mylar cards were positioned at 1, 2, 3, 5, 7, and 12 m downwind from the nozzle. Applications were performed in 4.4 m s^{-1} wind speeds. Dry weights of plants at 12 m were recorded at 28 days after application to determine the biomass reduction (BR). There was no interaction between herbicide and crop. Both herbicides produced similar BR for crops tested; however, soybeans had more BR compared with other crops using XR nozzle. Grasses and broadleaves had similar BR downwind when both herbicides were sprayed through TTI nozzle. Using AIXR nozzle, soybean had higher BR downwind than sorghum. The deposition on mylar cards decreased exponentially across nozzles as the distance increased. Similarly, it was also observed for BR of soybean and cotton for both herbicides sprayed through three nozzles.

SPRAY PARTICLE DRIFT OF DIFFERENT DICAMBA FORMULATIONS IN A WIND TUNNEL. Bruno Canella Vieira*[1], Guilherme Sousa Alves[2], Thalyson Medeiros de Santana[3], Camila Chiaranda Rodrigues[3], Vinicius Velho[3], Greg R Kruger[2]; [1]University of Nebraska, Lincoln, NE, [2]University of Nebraska, North Platte, NE, [3]University of Nebraska-Lincoln, North Platte, NE (104)

With the introduction of dicamba tolerant crops, growers have a new option to control troublesome glyphosate-resistant weeds on soybean and cotton. However, the technology had issues regarding off-target movement and unintended herbicide injury on surrounding vegetation in its first two years of adoption. Along with tank contamination and volatilization, application particle drift is suspected to be among the key factors responsible for the dicamba injury cases. The objective of this study was to investigate the droplet size distribution and the drift potential of new dicamba with glyphosate pre-mixture and tank-mixture formulations. The study was conducted in a low-speed wind tunnel at the Pesticide Application Technology Laboratory, North Platte, NE. Dicamba choline + glyphosate pre-mixture (choline), dicamba BAPMA + glyphosate tank-mixture (BAPMA), and dicamba DGA + glyphosate tank-mixture (DGA) were tested. Dicamba + glyphosate treatments were prepared at 560 and 932 g ae ha-1, respectively, at a carrier volume of 140 L ha-1. Applications were performed with a TTI110015 nozzle operated at 276 kPa. A Sympatec HELOS/KR laser diffraction instrument was used for droplet sizing measurements and the DV10, DV50, DV90, and percentage of volume with droplets smaller than 200 µm (driftable fines) were reported. Particle drift potential was estimated in a low-speed wind tunnel (16 km hr-1 airstream) as drift collectors and glyphosate-resistant (non-dicamba-tolerant) soybean plants (V3) were positioned at 0.5, 1, 2, 4, 6, 9, and 12 m downwind from the applications. Particle drift potential was estimated with soybean biomass reduction data and fluorimetry analysis as PTSA (fluorescent tracer) was added to the tank solution (2 g L-1). The experiment had a completely randomized design with five replications and was conducted twice. Droplet size data were subjected to analysis of variance in SAS software and comparisons among solutions were performed using Fisher's Protected LSD test (a=0.05). Biomass reduction and drift deposition data were analyzed with a non-linear regression model using the drc package in R software. The choline pre-mixture solution had smaller DV50 (825 µm) when compared to BAPMA (912 µm) and DGA (917 µm) tank-mixtures. The choline pre-mixture had slightly more driftable fines (1.1 %) when compared to the other solutions (0.7%). Drift deposition results indicated that solutions had similar drift deposition profile. Similar trend was observed in the biomass reduction data, where applications with choline, BAPMA, and DGA solutions had 50% soybean biomass reduction estimations at 4.7, 4, and 5 m, respectively. Additional information on soybean injury associated with dicamba particle drift potential provides a better understanding of dicamba related injury cases and off-target movement potential changes between formulations.

DETECTION AND FREQUENCY OF LOW LEVEL TEMPERATURE INVERSIONS IN MINNESOTA. David Nicolai*[1], Jared J. Goplen[2], Ryan P. Miller[3], Andrew A. Thostenson[4]; [1]University of Minnesota, Farmington, MN, [2]University of Minnesota, Morris, MN, [3]University of Minnesota, Rochester, MN, [4]North Dakota State University, Fargo, MN (105)

Air temperature inversions are an environmental phenomenon that have long been recognized to adversely impact the deposition of fine spray drops. In addition, air stability near the earth surface allows for the accumulation of volatile pesticide molecules which may easily move down range in a light breeze to non-target sites. For standardization between sites, we decided to measure air temperatures at one m and three m above the Earth's surface, with one m roughly representing spray boom height. Many crop protection chemical labels prohibit applications during the occurrence of low level temperature inversions. We used a 0.3 C inversion detection threshold. When the temperature at three m was 0.3 C warmer than the temperature at one m, we tended to see temperature readings stabilize, and we were within the accuracy limits of our sensors. Temperature inversion data was collected in the month of June in multiple locations in Minnesota and North Dakota. In Minnesota temperature inversion data was collected with a ONSET HOBO MX2303 dual external temperature sensor equipped with the ONSET RS3-B solar radiation shields. Temperature sensors were installed on a weather station at one and three m to detect presence or absence of a low level temperature inversions. In North Dakota, NDAWN stations were utilized as a source of temperature inversion data. The NDAWN stations utilize Vaisala HMP temperature/humidity sensors mounted in gill shields and are attached to Campbell Scientific steel weather stations. Key findings indicate that low-level temperature inversions occur in every 24 hr day except those with precipitation, severe weather, or very high wind speeds throughout the nighttime hr. Inversions typically start to build in late afternoon, often 2-2.5 hr before sunset. It is still unknown what level of intensity signifies a meaningful temperature inversion, but improving our understanding of when temperature inversions most-often occur will help applicators avoid spraying pesticides into temperature inversions. Ultimately this will help minimize off-target movement of pesticides.

THE INFLUENCE OF PREEMERGENCE HERBICIDES AND MECHANICAL INCORPORATION ON COVER CROP ESTABLISHMENT AND GRAIN YIELD IN *ZEA MAYS*. Lizabeth Stahl*[1], Ryan P. Miller[2], Jared J. Goplen[3], Lisa M. Behnken[4]; [1]University of

Minnesota, Worthington, MN, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota, Morris, MN, [4]University of Minnesota Extension, Rochester, MN (106)

Field research was conducted at Rochester, MN in 2018 to determine the influence of pre-emergence (PRE) herbicides and incorporation on cover crop establishment and grain yield in *Zea mays*. A split-plot randomized complete block design with four replications was used. Corn hybrid variety 'DKC 51-38' was planted 5 cm deep in 76-cm rows at a rate of 79,000 seeds ha^{-1} on May 7, 2018. Herbicide applications were made at 6.4 kph with a tractor-mounted sprayer delivering 141 L ha^{-1} at 276 pKa using TTI110015 nozzles. Treatments were made according to label instructions and adequate rainfall was received after each treatment. PRE treatments included: no PRE herbicide; dimethenamide-P (Outlook) at 192 ml ha^{-1}; saflufenacil (Sharpen) at 36 ml ha^{-1}; dimethenamide-P and saflufenacil (Verdict) at 180 ml ha^{-1}. PRE treatments were followed by a postemergence (POST) treatment of glyphosate (Roundup Powermax) at 384 ml ha^{-1}. A cover crop blend consisting of *Secale cereale* (cereal rye) at 56 kg ha^{-1}, *Brassica napus* (dwarf 'essex' rape) at 6.7 kg ha^{-1}, and *Trifolium alexandrinum* (berseem clover) at 9 kg ha^{-1} was hand seeded six days after application (DAA) of the glyphosate into V5 corn. The main plot treatment was either incorporation or no incorporation of the cover crop seed with a Lilliston rolling cultivator. The Lilliston rolling cultivator was run at 11-13 kph and was set to cultivate soil away from the base of the corn stalk. Weeds were rated for visual estimation of control and cover crop density was determined by counting plants in three 0.01 m^2 quadrats $plot^{-1}$. Plots were machine harvested and yields were calculated and adjusted to 15% moisture. PRE herbicide applications generally resulted in greater than 90% weed control at 17 DAA, with the exception of Sharpen which provided no grass weed control. Cultivation or PRE treatments did not affect cereal rye establishment. Berseem clover establishment was greatest with cultivation and PRE effects were inconsistent. Dwarf 'essex' rape establishment was better where cultivation was implemented and had better establishment with either Outlook or no PRE. *Amaranthus tuberculatus* (waterhemp) and *Chenopodium album* (common lambsquarters) populations, which were evaluated the same time as cover crop establishment, were not affected by cultivation or PRE. Cover crop densities declined during August and were almost nonexistent at the time of harvest. The exception was Dwarf 'Essex' Rape, which had a substantial number of surviving plants in the plots that were cultivated and had no PRE applied.

FARMER SURVEY RESULTS HIGHLIGHT TRENDS IN WEED MANAGEMENT PRACTICES. Lizabeth Stahl*[1], Lisa M. Behnken[2], Fritz Breitenbach[2], Ryan P. Miller[3], David Nicolai[4]; [1]University of Minnesota, Worthington, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota, Rochester, MN, [4]University of Minnesota, Farmington, MN (107)

Each year since 2003, farmers who attended Private Pesticide Applicator workshops across southern Minnesota participated in an Integrated Pest Management (IPM) assessment that was incorporated into the program. Private Pesticide recertfication is on a three-year cycle in Minnesota, so the group surveyed every three years was similar (e.g. an average of 79% of the farmers surveyed in 2016-2018 attended a workshop three years prior). Responses were initially collected through paper surveys, but since 2008 Turning Technologies' ResponseCards have been used. Survey results illustrate the challenges farmers are facing in dealing with herbicide-resistant weeds. By far the most common issue reported was resistance to glyphosate with 76% of the respondents in 2018 reporting that they felt they had glyphosate-resistant weeds on the land they farm, up from 31% in 2008. In comparison, 19% of respondents felt they had resistance to PPO-inhibitors and 18% of respondents felt they had resistance to ALS-inhibitors in 2018. Although the percent of farmers who actually have ALS-resistant weeds is likely greater due to historical issues with ALS-resistant weeds in corn and soybean in Minnesota, the perception is that this trait is not very common anymore. Only 19% of respondents in 2018 felt they did not have herbicide-resistant weeds on the land they farmed. Results also reveal trends in what tactics farmers are using in their weed management programs. Use of pre-emergence (PRE) or pre-plant residual herbicides has increased greatly in soybean, and to a lesser extent in corn. From 2009 to 2011, 60 to 71% of respondents used a postemergence (POST)-only program in soybean while 40 to 50% used a POST-only program in corn. In contrast, 73 and 66% of the respondents in 2018 indicted they used a PRE or pre-plant residual herbicide on all of their soybean and corn acres, respectively. Respondents were also asked about their use of cultural and mechanical weed control methods. Mechanical weed control methods (e.g. rotary hoe, inter-row cultivation) continue to be used by a low percentage of respondents, staying at 10% or less from 2013 to 2017, although reported use increased to 17% in 2018. In contrast, hand-pulling of weeds has been increasing in use. In 2015, 12% of the respondents reported they hand-pulled weeds, while in 2018, 35% of respondents reported they hand-pulled weeds. After hand-pulling of weeds, altering the planned crop rotation was the next most commonly-used non-chemical weed control practice in 2017 (21% of respondents) and 2018 (28% of respondents). Information on how farmers are adapting their weed control methods, and what practices they are more likely to implement, has been useful when developing educational programming around the management of herbicide-resistant weeds.

2018 WISCONSIN CROPPING SYSTEMS WEED SCIENCE SURVEY - WHERE ARE WE AT? Lina Liu*, Maxwel Coura Oliveira, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (108)

Weed management is a never-ending issue for crop growers across the US. Given that each state has unique cropping-systems and weed management strategies, the objective of this survey was to evaluate the main crop and weed management strategies adopted and the troublesome weed species present in Wisconsin. The survey was conducted during the Wisconsin Agronomy Update Meetings (eight locations) in January of 2018 where a total of 286 respondents, including agronomists, farmers, industry and coop representatives, representing 54 counties, completed the survey. The results show that corn, soybeans, alfalfa, and wheat, in this respective order, are the main crops managed by survey respondents. Tillage is a common practice in Wisconsin; 70% of 230 survey respondents adopt the strategy. In terms of troublesome weeds, waterhemp (69%), giant ragweed (51%), and common lambsquarters (19%), respectively, are the most concerning in Wisconsin cropping systems according to the survey respondents. Some of these weed species have evolved resistance to glyphosate in Wisconsin; waterhemp, giant ragweed, and horseweed were the main species reported. Although 55% of 214 respondents reported that there is no perceived presence of weed(s) resistant to herbicide site-of-action other than glyphosate, 18% of the respondents have reported the occurrence of ALS-resistance waterhemp, marestail and giant ragweed in Wisconsin. Currently, a one-pass herbicide program is still common, especially in corn (62%); 43% soybean growers use a one-pass herbicide program. There is a smaller likelihood (38%) for Wisconsin to adopt auxin-tolerant crops compared to the central and southern states, however, 77% of the 268 answerers expressed interest in adopting cover crops in Wisconsin. From the survey, we have learned that Wisconsin has very diversified cropping systems in terms of crop rotation and soil management strategies (e.g., high tillage adoption). The “delayed” occurrence (i.e., selection and distribution) of herbicide-resistant weeds in Wisconsin is likely due to the combination of intensified crop rotations and tillage. Even though the occurrence of herbicide-resistant weeds has been “delayed”, they are now widespread across the state. Farmers may need to adjust their herbicide programs in order to better manage herbicide-resistant weeds. Transition to a two-pass program, particularly in soybeans, may become necessary for control of the troublesome weeds with extended emergence window such as waterhemp, giant ragweed, and common lambsquarters that are becoming more prevalent in Wisconsin cropping systems. This adjustment to the herbicide program will enhance the control of these troublesome weeds and reduce the selection pressure on postemergence herbicides.

HERBICIDE RESISTANCE IN WISCONSIN: AN OVERVIEW. Joseph W. Zimbric*, David E. Stoltenberg, Mark Renz, Rodrigo Werle; University of Wisconsin-Madison, Madison, WI (109)

The first confirmed case of herbicide resistance in Wisconsin was PSII inhibitor (atrazine) resistance in common lambsquarters in 1979. Since then, 20 unique cases of herbicide resistance have been confirmed in the state, including 13 weed species with evolved resistance to one or more herbicide sites of action. ALS-inhibitor resistance has been confirmed in more weed species than other type of herbicide resistance, totaling eight weed species including common ragweed, giant ragweed, waterhemp, and Palmer amaranth. In comparison, PSII inhibitor resistance has been confirmed in four species, whereas ACCase-inhibitor resistance has been confirmed in only two species (giant foxtail and large crabgrass). The first confirmed case of glyphosate resistance in Wisconsin was giant ragweed in 2011. Glyphosate resistance has subsequently been confirmed in horseweed, waterhemp, Palmer amaranth, and most recently, common ragweed. In recent years, glyphosate resistance concerns have focused on waterhemp which has increased rapidly to include confirmed cases in 28 counties. Among these, multiple resistance to glyphosate and PPO-inhibitors has been confirmed in 10 counties. Herbicide resistance in Palmer amaranth has been limited to two cases of confirmed glyphosate resistance and one case of confirmed multiple resistance to ALS-inhibitors and the HPPD-inhibitor tembotrione. However, Palmer amaranth presence has been confirmed in nine counties and is perceived as a serious threat to crop production. It is critical that diversified management tactics be implemented to reduce the spread, persistence, and impact of these and other herbicide-resistant species. Current research is focused on characterizing herbicide resistance in pigweed and ragweed species.

DEMONSTRATING SOA COMPONENTS OF A HERBICIDE AS AN EXTENSION TEACHING TOOL. Ryan P. Miller*[1], Lisa M. Behnken[2]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN (110)

Understanding effective sites of action (SOA) of herbicides has been and will continue to be an important concept in chemical weed control. Unfortunately, the glyphosate era of weed control made chemical weed control easy, as glyphosate provided effective broad-spectrum control of many weeds in many different crops. Overreliance on glyphosate brought the "easy" era to an end. With this, came a lack of understanding of what different herbicide SOAs provide in terms of weed control. SOA demonstration trials of pre-emergence (PRE) herbicide pre-mixtures and their components were conducted in both corn and soybeans at Rochester, MN in 2018. Herbicide applications were made at 6.4 kph with a tractor-mounted sprayer 141 L ha^{-1} at 276 kPa using TTI110015 nozzles. Treatments were made according to label instructions and adequate rainfall was received after each treatment. No postemergence herbicides were applied to help highlight what each PRE and its respective components were providing in-terms of weed control. For the soybean trial, a full-labeled rate of each pre-mixture PRE and an equivalent rate of each individual herbicide component was applied. Soybean PREs included imazethypyr, saflufenacil, pyroxasulfone (Zidua Pro); cloransulam, sulfentrazone (Authority First); and acetochlor, fomesafen (Warrant Ultra). For the corn component trial, full-labeled rates, of each pre-mixture and equivalent rates of selected components were applied. The corn component trial did not include every component individually, but did include combinations of selected components. Corn PREs included mesotrione, bicyclopyrone, atrazine, S-metolachlor (Acuron), mesotrione, clopyralid, and acetochlor (Resicore). The goal of the two trials was to demonstrate what each component provided for weed control and to gain an understanding of how components work together to provide improved weed control as a complete herbicide program. Results were highly visual and served as an effective teaching tool to demonstrate the concept of effective sites of action. The demonstration plots also allowed agriculturists to confirm observations they had made in production fields. For example, in recent years, *Abutilon theophrasti* (velvetleaf) has become more prevalent in MN soybean fields. Warrant Ultra treatments in the soybean SOA trial helped illustrate a potential reason for this observation as this product and its components did not provide acceptable velvetleaf control. Approximately 100 farmers and agricultural professionals were able to see for themselves and learn about effective SOAs during an educational field day in July. An additional 200 agricultural professionals and farmers took the opportunity to look and learn by touring the field demonstrations throughout July and August as individuals or small groups. The general impression by those who toured the plots was very positive. Many found these demonstrations very valuable because they lacked knowledge, training and experience with individual SOA's performance in the field.

ASSESSMENT OF COVER CROP PLANTING DATE ON WINTER ANNUAL WEED SUPPRESSION. Kolby R. Grint*, Christopher Proctor, Joshua S. Wehrbein; University of Nebraska-Lincoln, Lincoln, NE (111)

Fall planted cover crops are becoming increasingly popular because of benefits they can provide to the crop production system, including the potential suppression of winter annual weeds. In the North Central Region of the US, cover crops are planted following corn (*Zea mays* L.) or soybean (*Glycine max* L.) harvest. The limits the potential of cover crops to produce sufficient biomass for winter annual weed suppression because of the relatively short growing season that remains. Research was conducted at the University of Nebraska - Lincoln Havelock Research Farm in 2017 and 2018 to examine the effects of climate in eastern Nebraska on cover crop biomass production and its effects on winter annual weed suppression. Cereal rye (*Secale cereale* L.) and a cereal rye/oat (*Avena sativa* L.) mixture were planted twice wk^{-1}, weather permitting, starting the second wk of September and continuing through the second wk of November. Cover crop treatments were planted with a nine-row grain drill on 19-cm row spacing. Weed density data were collected in the fall after cover crop growth ceased and harvest of aboveground weed biomass occurred in the spring prior to cover crop termination. Cover crop biomass was sampled in the fall prior to oat termination and in the spring prior to cereal rye termination. Earlier planting dates have been shown to produce greater cover crop biomass with additional biomass from oats in early plantings during the fall compared to rye alone. Earlier planting dates are expected to provide increased suppression of winter annual weeds through enhanced biomass production, with reduced or no weed suppression for late planting dates. Data collected from this study will help producers make cover crop planting and management decisions to achieve suppression of winter annual weeds.

USE OF TABLEAU TO VISUALIZE INVASIVE PLANT DISTRIBUTION IN WISCONSIN. Niels A. Jorgensen*[1], Mark Renz[2]; [1]University of Wisconsin, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI (112)

In this decade alone, the volume of data worldwide continues to double every two years, with expected exponential growth beyond 2020. New approaches to visualization of these datasets is required to make informed decisions. While custom approaches to visualization can be created, cost in maintenance of these systems often prevents their development. New software is becoming more ubiquitously available that streamlines the visualization process. Here, we discuss the use of Tableau to visualize regulated invasive species data in Wisconsin. Tableau is a business intelligence (BI) platform designed to meet the growing challenges posed by expanding data availability. It offers tools to help clean, reorganize, evaluate, analyze and visualize complex datasets in a user friendly environment. With its recent expansion of interactive mapping tools, online Public domain, and free availability to students, Tableau now offers a wide spectrum of capabilities that make it highly attractive for research and Extension purposes. We used Tableau to display regulated invasive plant data from disparate sources in a new tool called the Wisconsin Shared Terrestrial Invasive Plant Presence (WISTIPP) Viewer. The WISTIPP Viewer is an online visualization tool (through Tableau Public) that gives the public access to view and download terrestrial invasive plant reports in Wisconsin. It currently contains over 112,800 observations from 120 regulated species (by Wisconsin Department of Natural Resources) over the past 100+ years. Users can view all records or customize the view using filters for the WI DNR's NR40 classification, species of interest, or time frame. Additionally, users can select individual records of interest or select records on the map as a group. Finally, the user has the ability to download the data behind the visualization. This includes the options to extract the selected records on the map as a CSV or crosstab, or export as an image file or PDF. While considerable time was spent in arranging the data to load into Tableau, the creation of the visualization took less than a day. An additional benefit of this software is that is allows for automatic real-time, or manual, updating of information. Currently, we update our dataset biweekly, a process that takes less than 15 minutes. WISTIPP has been viewed or used to extract information over 550 times since its launch in August 2018. Here, we show that Tableau offers a flexible platform to extend information to the public. While cost can be expense for industry, currently it is available for free to academic institutions.

SURVEY OF NEBRASKA AND WISCONSIN SOYBEAN PRODUCERS ON DICAMBA USE DURING 2017 AND 2018. Rodrigo Werle*[1], Christopher Proctor[2], Paul Mitchell[1], Amit Jhala[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Nebraska-Lincoln, Lincoln, NE (113)

Due to off-target dicamba movement incidents during the 2017 and 2018 growing seasons, adoption of the Xtend technology (dicamba- and glyphosate-tolerant soybeans) has become a controversial topic in the US. From August through September of 2018, a survey containing 22 questions related to soybean, dicamba and weed management was conducted with 316 and 149 stakeholders from Nebraska and Wisconsin, respectively. The objective of the survey was to understand Nebraska and Wisconsin stakeholders' adoption and opinion related to the Xtend technology. Respondents were grouped into two categories: i) growers and ii) decision influencers (agronomists, coop, industry and university representatives). According to growers, in 2018, 53 and 31% of their managed hectares were planted with Xtend soybean cultivars in Nebraska and Wisconsin, respectively. In 2019, they expect to increase the Xtend soybean hectares in 11 and 17% in Nebraska and Wisconsin, respectively. According to growers and decision influencers from Nebraska, 42% of Xtend soybean hectares were sprayed pre-emergence (PRE) and nearly 65% postemergence (POST). In Wisconsin, <25% and 45% of Xtend hectares were sprayed with dicamba PRE and POST, respectively. In Nebraska, over 90% of respondents use/recommend an effective PRE program with multiple sites-of-action (SOA) whereas in Wisconsin approximately 75% do. Weed management improved with adoption of the Xtend soybean technology according to >80% respondents from Nebraska; in Wisconsin, improvement in weed control was reported by 66% of growers and 75% of decision influencers. Approximately 75% of Nebraska and Wisconsin growers who participated in this survey own a sprayer and spray their herbicide programs. Nebraska and Wisconsin respondents that sprayed dicamba in Xtend soybeans in 2018 used a labeled formulation (i.e., Engenia, FeXapan, or XtendiMax). Less than 10% of survey respondents from Nebraska and Wisconsin reported that their dicamba application in Xtend soybeans injured neighboring sensitive soybeans. However, nearly 50% (Nebraska) and 20% (Wisconsin) of respondents (growers and decision makers) noticed dicamba injury on their non-Xtend soybeans. Three percent of growers from Nebraska filed an official off-target dicamba complaint with the Department of Agriculture; Wisconsin respondents that observed injury on their non-Xtend soybeans did not file an official complaint. When asked the main cause for dicamba injury on non-Xtend soybeans, physical drift and volatilization from dicamba either applied in Xtend soybeans or in corn (e.g., Status) were the main answers in both states. Here we present a summary of the adoption of Xtend technology in two distinct states. Faster adoption of the technology in Nebraska is likely due to bigger challenges faced with the widespread presence of herbicide-resistant weeds when compared to Wisconsin. In general, Nebraska and Wisconsin growers tended to be more conservative in their answers than decision influencers. These survey responses will aid growers and decision influencers understand current and future adoption of the Xtend technology in the upper Midwest.

DOES A LIABILITY JURY DECISION CHANGE THE TOXICOLOGY OF ROUNDUP. Allan Felsot*; Washington State University, Richland, WA (115)

During August 2018, a California jury ruled in favor of an applicator plaintiff who claimed that Monsanto, the manufacturer of Roundup products containing the active ingredient glyphosate, provided inadequate warning for use of the product and as a result had contracted a form of non-Hodgkin's Lymphoma, an immune system cancer. The basis of the liability lawsuit is arguably directly linked to the International Agency for Research on Cancer (IARC) conclusion that glyphosate is probably a human carcinogen. IARC is funded by the UN World Health Organization (WHO). Ironically, another WHO funded agency, the Joint Meeting on Pesticide Residues (JMPR), as well as regulatory agencies like the EPA, have concluded glyphosate does not pose a hazard when used as mandated by the label. This presentation will review the evidence on glyphosate toxicology and epidemiology.

NEW FINDINGS ON ULTRA-COARSE SPRAYS AND TEST METHODS. Daniel C. Bissell*[1], Chris Hogan[2], Bernard Olson[2], Lillian c. Magidow[1], Gregory K. Dahl[1], Joe V. Gednalske[1]; [1]Winfield United, River Falls, WI, [2]University of Minnesota, Minneapolis, MN (119)

Spray based application of crop protectants requires accurate measurement of the drop size distribution of the spray used in order to correctly predict the deposition location of the spray, and to determine guidelines for spraying to minimize off target deposition. Measurements of such spray drop distributions are typically performed in low speed wind tunnels using Laser Diffraction (LD) measurements to obtain the volume distribution of the spray. Herein a second drop sizing method, Phase Doppler Particle Analysis (PDPA) was employed and the results compared to LD measurements of two ultra-course sprays and one medium spray. The spray drop size distributions were evaluated the basis of their volume distribution, which is a description of what size droplets the liquid volume of the spray is partitioned into and is biased towards large droplets as volume is proportional to diameter cubed. They were hence also evaluated based on their number distribution, which is the total count of droplets of each size and gives a more accurate representation of how the spray is transported from the nozzle to deposition location. It was found that the LD measurements typically exhibited a truncated number distribution measurement, with no drops appreciably smaller than the peak diameter measured, and the PDPA measurements revealed drops with an expected log normal distribution. Additionally the PDPA measurements typically had peak values smaller than the LD measurements on the basis of number distribution, but peak values larger than the LD measurements on the basis of volume distribution, possibly skewed by measurement artifacts at large sizes. This work shows that caution needs to be exercised when interpreting spray drop size distribution measurements and we suggest that both the number and volume distributions should be considered in assessing the potential of a nozzle and tank-mixture combination for spray drift and overspray.

LIQUID LOGICNEW SPRAYER TECHNOLOGY THAT DRASTICALLY REDUCES THE TIME REQUIRED FOR SPRAYER CLEANOUT AND SOLVES BOOM PRIMING ISSUES. Craig Jorgensen*; AGCO Corp, Jackson, MN (120)

AGCO Corporation recently released a new RoGator in 2017 with Liquid Logic. Liquid Logic encompasses several new sprayer technologies that help solve many issues sprayer operators are facing. One of the most exciting new features would be the recirculating boom. The plumbing is designed to allow product to flow through the boom and back to the tank. This provides many benefits including better product filtration, elimination of product settling out in the boom, eliminating air trapped in the boom, eliminating the need to spray 40-50 gallons through the boom to prime the boom with a new herbicide and drastically reducing the time needed to do sprayer clean out. The recirculating boom also speeds up sprayer clean out. Since there are no dead end spaces on the boom the operator can push rinsate with tank cleaner through the boom and back to the tank, completely cleaning all aspects of the boom without the need to remove end caps or aspirators on the boom. Another new and exciting feature is product recovery. Product recovery allows the operator of the sprayer to use air and move the product that is in the boom and bring it back to the tank. In the event that a spray operator gets rained out while spraying something that settles out, like Atrazine, they no longer only have the option to blow the material out of the boom and onto the ground to prevent plugged nozzles. The product recovery allows them to return the material back to the tank where agitation can be done to get the product back in suspension. Once material is back in the tank the sprayer operator also has the option to introduce fresh water into the boom even though there is chemical in the tank. Product recovery can also be preformed before a tank/ boom rinse, allowing the spray operator to capture all of the remaining product in the boom and reuse it the next time that product is sprayed. Some other new and exciting features include an automated agitation feature that can be programmed to adjust agitation automatically based upon tank volume. The auto agitation will also shut off the agitation at a programmed level to eliminate foaming of chemicals in the tank. When refilling the tank the agitation will resume automatically once the minimum level for agitation has been reached. E-Stop nozzle bodies eliminate the spitting and sputtering of normal diaphragm nozzle bodies. The E-stops are actually a stainless steel ball valve so it does not require a certain amount of pressure to open or close. The ball valve is either completely open or shut. Overlap is much less of a concern with the Liquid Logic spray system as well. As many as 36 sections, which are ISO sections, are provided directly from the manufacturer. Pulse width modulation systems are also an option for nozzle by nozzle control. The Liquid Logic system from AGCO Corp is the only recirculating boom system manufactured in North America and provides many agronomic and environmental advantages over conventional spray systems.

REDUCING SPRAY DRIFT AND INCREASING SPRAY DAYS WITH REDBALL-HOODED™ SPRAYERS - A DRIFT COMPARISON OF A REDBALL-HOODED BOOM VERSUS AN OPEN BOOM, AND AN OVERVIEW OF AVAILABLE LEGAL SPRAY DAYS IN 2018. Steve W. Claussen*; Willmar Fabrication, LLC, Benson, MN (121)

Herbicide spray drift continues to be an important issue for the agriculture industry. However, it's not just drift from herbicides that are causing a concern. Spray drift from pyrethroids could cause significant damage to vulnerable pollinators. Applicators need a safe and efficient way to apply all chemicals. Redball-Hooded™ Sprayers are one of the best tools available to reduce spray drift. The Redball® Gen II Broadcast Hood's unique design encloses the spray and prevents most pesticide exposure from the wind, therefore, reducing drift. Tests were conducted with a Redball-Hooded boom and an open boom using water sensitive paper to illustrate the difference in drift at different wind speeds (16 kph and 24 kph) and with different tips [AIXR11003 (Very Coarse) and XR11003 (Fine)]. Regardless of wind speed or tip, when used Redball-Hoods reduced drift in the tests. Redball Hoods can also assist applicators to make timely applications. During June we tracked rain, wind, and temperature across the US and analyzed the data to determine available spray days in 2018.

SPRAY PARTICLE DRIFT MITIGATION USING FIELD CORN AS A DRIFT BARRIER. Bruno Canella Vieira*[1], Thomas R. Butts[2], Andre de Oliveira Rodrigues[3], Jeffrey Golus[4], Kasey Schroeder[4], Greg R Kruger[3]; [1]University of Nebraska, Lincoln, NE, [2]University of Arkansas, Lonoke, AR, [3]University of Nebraska, North Platte, NE, [4]University of Nebraska-Lincoln, North Platte, NE (122)

Particle drift from herbicide applications can reduce efficacy and impact nearby vegetation depending on the herbicide mode-of-action, exposure level, and tolerance to the herbicide. Particle drift mitigation efforts placing windbreaks or barriers on field boundaries have been utilized in the past. The objective of this research was to evaluate the effectiveness of field corn (Zea mays L.) at different heights as a particle drift barrier. A field experiment was conducted in the West Central Water Resources Field Laboratory, University of Nebraska – Lincoln near Brule, NE. Eight corn rows were planted at three different timings (70 m sections) and maintained on the edge of the experimental field prior to the study application. At the time of application, corn plants were 91-, 122-, and 198-cm tall for the three planting timings. Applications (94 L ha-1) were made with a self-propelled sprayer using a 30.5 m boom. A tank solution of water and 600 ppm fluorescent tracer PTSA (1,3,6,8-pyrene tetra sulfonic acid tetra sodium salt) was sprayed at 276 kPa with two different nozzles: ER11004 (Fine droplets) and TTI11004 (Ultra Coarse droplets). Applications were made from east to west in a south crosswind 12 times for each nozzle in a completely randomized design. Mylar cards (100 cm2) were used as drift collectors at different downwind distances (0, 2, 5, 10, 14, 22, 29, 105, 32, 53, and 70 m) from the treated area of each corn section (no corn, 91-, 122-, and 198-cm tall). Drift (%) was estimated for each downwind collector by fluorimetry analysis. A double exponential decay model was fitted to the data using the gnm package in R. Applications with a non-air inclusion flat fan nozzle (ER11004) resulted in greater particle drift when compared to an air inclusion nozzle (TTI11004). Applications with the ER11004 nozzle without corn barriers had 1% of the applied rate (D99) predicted to deposit at 14.8 m downwind, whereas this distance was reduced (up to 7-fold) when applications were performed with corn barriers. The combination of corn drift barriers and nozzle selection (TTI11004) provided the greatest particle drift reduction when the D99 estimates were compared to applications with the ER11004 nozzle without corn barriers (up to 10-fold difference). The corn drift barriers were effective in reducing particle drift.

ADVANCED SPRAY SYSTEM TECHNOLOGY FROM JOHN DEERE. Yancy E. Wright*; John Deere, Shawnee, KS (123)

Application technology that can mitigate off-target drift or be productive during the brief windows when drift risk is low should be considered and recommended throughout the industry. John Deere is a provider of advanced application equipment technology. Spray system technology such as the John Deere ExactApply nozzle control system with compatible John Deere Low Drift Max (LDM) spray nozzles, broad (36 and 40 m) sprayer booms, automatic boom height control, direct injection (DI) and Load Command are technologies available to spray during optimal, low-risk time periods and reduce the amount of in-field and out-of-field crop damage. A comprehensive review of available application technologies is needed for weed science professionals as they carry out research and extension work to balance new weed control technologies with unintended crop damage.

NOZZLE SELECTION AND ADJUVANT IMPACT ON THE EFFICACY OF GLYPHOSATE AND GLUFOSINATE TANK-MIXED WITH PPO-INHIBITING HERBICIDES. Jesaelen Gizotti de Moraes*[1], Camila Chiaranda Rodrigues[1], Debora O. Latorre[1], Greg R Kruger[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (124)

Glyphosate or glufosinate have been extensively tank-mixed with PPO-inhibiting herbicides applied to genetically modified crops to broaden weed control while managing herbicide-resistant weeds. Glufosinate and PPO-inhibitors are classified as fast acting herbicides whereas glyphosate as a systemic herbicide that must translocate into the plant to maximize activity. More information about how these herbicides and adjuvants interact when applied in combination as well as the droplet size produced from these tank-mixtures are needed. Therefore, the objectives of this study were to evaluate any possible interaction and to determine the impact of nozzle selection and adjuvants on the efficacy of glyphosate or glufosinate applied alone or in tank-mixtures with PPO-inhibiting herbicides. Four weed species were used: kochia (*Kochia scoparia* (L.) Schrad.), horseweed (*Conyza canadensis* (L.) Cronq.), common lambsquarters (*Chenopodium album* L.), and grain sorghum (*Sorghum bicolor* (L.) Moench ssp. *Bicolor*). Treatments were arranged in a 10 x 2 factorial consisting of ten spray solutions and two nozzle types (XR11004 and TTI11004). Spray treatments consisted of postemergence applications of glyphosate at 630 g ae ha^{-1}, glufosinate at 212 g ai ha^{-1}, lactofen at 110 g ai ha^{-1}, or lactofen at 110 g ai ha^{-1} with crop oil concentrate (COC) at 1% v v^{-1}, non-ionic surfactant (NIS) at 0.25% v v^{-1}, methylated seed oil (MSO) at 1% v v^{-1}, or a drift reducing agent (DRA) at 0.5% v v^{-1}, and either glyphosate or glufosinate with lactofen in combination with each of the adjuvants aforementioned. All applications were performed at 276 kPa and 2.7 m s^{-1} to deliver 187 L ha^{-1} using a three-nozzle laboratory track sprayer. Droplet size spectra were also recorded using a laser diffraction system. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test with the Tukey adjustment. Although the interaction between nozzle and solution were all significant for droplet size spectra, the nozzle effect had a greater impact when using glufosinate. The XR nozzle had the highest level of weed control when using glufosinate. Increased percent of fine droplets

(<150 µm) produced was observed by the interaction between nozzle and solution, particularly when glyphosate was used alone in combination with the XR nozzle. Finer droplets may be required when using mixtures containing glufosinate herbicide applied to horseweed and common lambsquarters whereas kochia and grain sorghum, as well as mixtures containing glyphosate, coarser droplets would be recommended to minimize drift potential of the spray solution without any cost of reduced efficacy. Antagonistic interactions were observed in specific treatments and mainly present when using glyphosate. Fast acting herbicides seem to reduce the translocation of systemic herbicides when using tank-mixtures. The addition of adjuvants into the tank-mixture may help overcome antagonism; however, optimum control is both adjuvant and weed species specific.

LARGE SCALE DRIFT TRIALS TO ASSESS OFF-TARGET MOVEMENT OF DICAMBA. Greg R Kruger*[1], Guilherme Sousa Alves[1], Dan Reynolds[2], Bryan G. Young[3], Peter Sikkema[4], Christy Sprague[5], Rodrigo Werle[6], Jason K. Norsworthy[7], Ryan Rector[8]; [1]University of Nebraska, North Platte, NE, [2]Mississippi State University, Mississippi State, MS, [3]Purdue University, West Lafayette, IN, [4]University of Guelph, Ridgetown, ON, [5]Michigan State University, E Lansing, MI, [6]University of Wisconsin-Madison, Madison, WI, [7]University of Arkansas, Fayetteville, AR, [8]Bayer Crop Science, St. Charles, MO (125)

Off-target movement of dicamba has dominated the headlines in agriculture over the last two years. The off-target movement of dicamba has occurred because of tank contamination, physical particle drift, volatility and run-off among other things. The new products (Engenia, FeXapan and Xtendimax) have been widely purported to reduce volatility, but yet massive areas of non-dicamba-tolerant soybeans have been reported to be damaged. A more thorough understanding of off-target movement of dicamba is necessary. The objective of this research was to quantify the off-target movement of dicamba from applications that followed the label across the Midwest and Mid-south US. Studies were conducted in Ontario, Canada and in Wisconsin, Michigan, Indiana, Nebraska, and Arkansas in the summer of 2018. Air samples were collected from the center mast in each location as well as the perimeter. Additionally, filter papers were collected from three transects in the downwind direction of the application area. Samples were analyzed using LC-MS-MS-MS and data modelled using the Aerodynamic Flux Model (AD) and/or the Integrated Horizontal Flux Model (IHF) as appropriate for the available data. When modelling each location, they were all within four fold of each other in terms of predicted flux. Sites, other than NE, were within one fold. Sites showed the diurnal flux across the three days following application with peaks during the daytime and lulls during the night. Also, each location showed a maximum peak, in terms of flux, during the first 24 hr and it dropped each day following. The AD and IHF were similar, but the AD seemed to be more stable and predictive of the actual numbers measured, likely due to the addition of wind speed and temperature measurements at each sampling height into the model. Either way, despite drastic differences in other measurements made (i.e. reported crop injury), the flux off of the applications sites seemed to be low and consistent between locations and within the reported flux values of previously reported studies on dicamba flux.

INFLUENCE OF SPRAY NOZZLE DESIGN AND WEED DENSITY ON HERBICIDE COVERAGE AND DEPOSITION. Madison D. Kramer*[1], Zachary K. Perry[1], Travis R. Legleiter[2]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY (126)

Dicamba injury to soybean due to drift has been a major concern and a series of restrictions have been created for dicamba applications. One restriction is the use of low drift nozzles that have been approved to spray dicamba, these nozzles produce extremely coarse and ultra-coarse droplets and minimize the production of driftable fines. An experiment was conducted in 2018 at the University of Kentucky Research and Education Center in Princeton, Kentucky to evaluate herbicide coverage and deposition on *Eleusine indica*. Specifically, looking at the influence of spray nozzle design and weed density. Dicamba plus glyphosate was applied to 5- to 10-cm tall weeds with Turbo TeeJet (TT11005) nozzle and two drift reduction nozzles approved for dicamba applications: Turbo TeeJet Induction (TTI11005) and Pentatir Ultra Lo-Drift (ULD12005). Fluorescent dye (PTSA) and pink foam marker dye were added to the spray solution to evaluate deposition on target leaf surfaces within the soybean canopy and evaluate coverage on Kromekote spray cards, respectively. Applications were made with an ATV traveling at 16 kph with an output of 140 L ha^{-1}. A 0.25 m^2 quadrant was established in each plot prior to the postemergence application with *E. indica* densities ranging from an average of 6 to 25 plants $quadrant^{-1}$. The coverage and depositions cm^{-2} was less for the two drift reduction nozzles as compared to the Turbo TeeJet. Deposition of spray solution on to *E. indica* were not different despite differences observed on the Kromekote cards. *E. indica* density also did not have an influence on spray solution deposition. The data collected from this research has shown that drift reduction nozzles and weed density may not reduce herbicide efficacy onto *E. indica* due to spray solution deposition being equivalent across nozzle types used in this study.

PARTITIONING OFF-TARGET MOVEMENT OF DICAMBA BETWEEN PARTICLES AND VAPORTS: A FIRST ATTEMPT. Greg R Kruger*[1], Guilherme Sousa Alves[1], Jeffrey Golus[2], Kasey Schroeder[2], Dan Reynolds[3], Darrin Dodds[4], Bradley K. Fritz[5], Clint Hoffmann[6], Ashli Brown Johnson[7], Ashley Meredith[7]; [1]University of Nebraska, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]Mississippi State University, Mississippi State, MS, [4]Mississippi State University, Starkville, MS, [5]USDA:ARS, College Station, TX, [6]Proloogy Consulting, College Station, TX, [7]Mississippi State Chemical Laboratory, Mississippi State, MS (127)

Dicamba drift and volatility have caused significant concern over the last three years in dicamba-tolerant crops. The approved dicamba labels for postemergence dicamba applications in soybean and cotton have extensive restrictions compared to many other pesticide labels. While some restrictions such as boom height, nozzle selection, and maximum operating pressure have clear direct impacts. Other things such as soybean growth stage likely have an effect as well, but it is not clear if the impact is from a direct effect or if it is indirectly affecting off-target movement because drift goes up later in the season because of increased temperatures, lower humidity and larger and more sensitive crops. The objective of this study was to determine if crop growth stage had a direct impact on off-target movement of dicamba. The study was designed with a center mast with air samplers with corresponding wind speed, wind direction, temperature and humidity at each height. Perimeter air samplers were located 16 m from the application area in all eight of the cardinal and intercardinal directions. Three downwind deposition transects were set up with filter papers along with the appropriate upwind controls. Two blocks, four ha each, of dicamba-tolerant soybean were set up a minimum of one km apart. One block was planted approximately three wk prior to the planting of the second block. Each block was surrounded by non-dicamba-tolerant soybean for a total of 16 ha blocks. The study was conducted in two fields near Sutherland, Nebraska and two fields near Brooksville, Mississippi during the summer of 2018. Applications were made with two sprayers set up identically at each location. Applications were made using TTI11004 nozzles operated at 276 kPa to deliver 141 L ha^{-1}. Applications were made using a tank-mixture of dicamba, glyphosate and gaur gum. Like other field drift and flux studies, we observed diurnal flux values with daytime samples being higher than nighttime samples and the first 24 hour samples being higher than the following 72 hours. The samples however showed very different results between the two locations with the first planted soybeans having higher flux values in one location and the later planted soybeans having higher flux values in the other location. More work is needed to better understand how crop growth stage affects (or doesn't affect) off-target movement.

REDESIGNING HSMSO ADJUVANTS: NOVEL TERPENE POLYMER CONTAINING FORMULATION. Patrick M. McMullan*[1], Mike Fiery[2]; [1]Ramulus LLC, Grimes, IA, [2]Miller Chemical & Fertilizer, LLC, Hanover, PA (128)

The majority of postemergence herbicide applications in corn, cotton, and soybeans consist of glyphosate tank-mixtures with additional herbicides, which can be either hydrophilic or lipophilic in nature. The majority of these tank-mixture partners require or recommend some type of oil-based adjuvant be included in the spray mixture. It is imperative that the oil-based adjuvant not negatively affect glyphosate efficacy. As defined by ASTM, high surfactant modified vegetable oil concentrates contain between 25 to 50% surfactant and a minimum of 50% modified vegetable oil (methylated seed oil is a type of modified vegetable oil). Typical high surfactant oil concentrates (HSOCs) contain 60% oil and the remainder being emulsifier with a minimum of 25% overall surfactant content in the formulation. ASTM definition allows for the incorporation of unique materials in the formulation. It is imperative that the unique formulations enhance pesticide performance. Pinolene® is a terpene polymer that increases deposition and the time for pesticide uptake that acts through extending the partition coefficient period with the leaf cuticle. Pinolene keeps the pesticide on the leaf surface in a liquid matrix, preventing drying out of the pesticide deposit while preventing washoff of pesticides. Three unique high surfactant oil concentrate adjuvants comprised of surfactant, methylated seed oil, and Pinolene were formulated and evaluated for enhancement of hydrophilic and lipophilic herbicide efficacy in the greenhouse. One formulation was selected based on its overall ability for herbicide efficacy enhancement and branded as Hybrid™. Numerous field efficacy trials have been conducted between 2015 and 2017 comparing Hybrid to other commercial HSMSO adjuvants for enhancement of both hydrophilic and lipophilic herbicide efficacy. Research results have shown that Hybrid consistently gave the highest efficacy over a number of weed species and number of herbicide chemistries. Hybrid is a novel HSMSO adjuvant with a unique combination of methylated seed oil and Pinolene technology. This unique combination provides for improved weed control and decreased crop injury compared to other HSMSO adjuvants.

COMPLIANCE WITH PESTICIDE LABELS ON SPRAY DROPLET SIZE AND CARRIER RATE TO MAXIMIZE PESTICIDE EFFICACY AND MANAGE SPRAY DRIFT. Robert N Klein*; University of Nebraska, North Platte, NE (129)

Research has indicated that spray density or coverage required for effective pesticide efficacy varies considerably with plant species, plant size, and growing conditions and with herbicide type and carrier volume. Larger spray droplets at low application volumes result in poor coverage. A droplet with twice the diameter of another has four times the area and eight times the volume. Many pesticide labels have the recommended or required spray droplet size and carrier rate on the label to maximize pesticide efficacy and manage spray drift. EC130, The Guide for Weed, Disease and Insect Management in Nebraska, has three pages, double columns on what is listed on the herbicide labels for either recommended or required spray droplet size (or sizes) for application. Along with droplet size is listed the carrier volume (GPA) on the label. One additional page with double columns lists the information for insecticides and fungicides. To assist applicators in nozzle tip selection and pressure to obtain the recommended or required spray droplet size, the Guide (EC130) has 10 charts: medium, coarse, very coarse at 10 GPA; extremely coarse and ultra coarse at 15 GPA; and medium, coarse, very coarse, extremely coarse and ultra coarse spray droplet sizes at 20 GPA. Two additional charts include glyphosate at 10 GPA and fungicide and insecticides at 15 and 20 GPA. The charts include 15, 20 and 30 inch nozzle spacing and speeds at 6, 7, 8, 10, 12 and 14 mph.

INFLUENCE OF PLANT GROWTH STAGE ON DICAMBA EFFICACY TO CONTROL PALMER AMARANTH. Ivan B. Cuvaca*[1], Randall S Currie[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS (130)

Rapid growth of Palmer amaranth poses a challenge for timely management of this weed. Although evolution of resistance to many commonly used herbicides in Midwestern cropping system is a challenge for Palmer amaranth management, dicamba can still offer an option to control this weed. Dose-response studies were conducted under field conditions in 2018 near Garden City, KS to evaluate the efficacy of dicamba to control Palmer amaranth at three stages of growth (≤10- (day 0), 15- (day 1), and 30-cm (day 4) tall plants). Visual estimations of weed control and reduction in dry biomass (% of non-treated) at four wk after treatment were assessed using a four- and three-parameter log-logistic model, respectively, in R software. Increasing dicamba doses increased Palmer amaranth control regardless of growth stage. Delaying dicamba application one (15-cm) or four days (30-cm) increased the effective dose of dicamba required to achieve 50% Palmer amaranth control (ED_{50}) greater than 2 and 27-fold, respectively. Similarly, the effective dose of dicamba required to cause 50% reduction in Palmer amaranth biomass (GR_{50}) increased more than four and eight-fold when dicamba application was delayed one (15-cm) or four days (30-cm), respectively. These results suggest that the efficacy of dicamba to control Palmer amaranth is strongly influenced by plant growth stage and, therefore, applications aimed at targeting plants >10 cm-tall should be avoided.

EFFECT OF DIFFERENT DEFOLIANTS/DESICCANTS ON SEED VIABILITY OF PALMER AMARANTH. Debalin Sarangi*[1], Kaisa M. Werner[1], Bojana Pilipovich[1], Peter A. Dotray[2], Muthukumar Bagavathiannan[1]; [1]Texas A&M University, College Station, TX, [2]Texas A&M University, Lubbock, TX (131)

Palmer amaranth is one of the most commonly encountered weed species in cotton production fields in Texas. Later emerging cohorts and late-season Palmer amaranth escapes can contribute to the seedbank recruitment and persistence. Application of harvest aids (defoliants/desiccants) at the time of cotton maturity is the common practice to facilitate the crop harvest. The objective of this study was to evaluate the effect of desiccants on seed viability of Palmer amaranth when they were applied at four different seed developmental stages (green, white, brown, and black seeds). Field experiments were conducted in 2018 at College Station, TX, using a factorial arrangement of treatments in a randomized complete block design with 10 replications to evaluate the effectiveness of eight different desiccants commonly used in cotton, along with a hand-clipped treatment and a non-treated control. The seedheads were harvested 28 days after treatment and threshed. A total number of fully developed and aborted seeds (shriveled seed coat) were counted, and the viability and dormancy of the fully developed seeds were tested by germinating them in petri-dishes followed by the tetrazolium test of the non-germinated seeds. Results showed that the application of desiccants affected the viable seed production by Palmer amaranth, however, the impact differed with different seed developmental stages and the desiccant treatments. Application of paraquat, glufosinate, dicamba, 2,4-D, pyraflufen-ethyl, and MSMA at black seed developmental stage reduced the viable seed production by ≥ 43% compared to the non-treated control. Desiccants with contact activity (e.g. paraquat, glufosinate, and MSMA), and dicamba had the most impact when applied to immature seedheads (green and white seed developmental stages). Overall, preliminary findings showed that late-season application of cotton desiccants can reduce viable seed production in Palmer amaranth, but proper selection of the desiccant and stage of application are critical.

EFFICACY OF SOYBEAN HERBICIDE RESPRAY APPLICATIONS ON PALMER AMARANTH AND WATERHEMP. Jesse A. Haarmann*, Bryan G. Young, William G. Johnson; Purdue University, West Lafayette, IN (132)

Contact herbicides can fail to adequately control weeds in a variety of situations, including: unfavorable application conditions, inadequate spray coverage and herbicide rate, or herbicide resistance. Surviving weeds are typically more branched, stressed, and can be more difficult to control as a result of the failed application. Choices for control of these weeds are often limited by crop herbicide tolerance, crop growth stage, and calendar date. The objective of this research was to determine the most effective herbicide choice and application timing to control Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*A. tuberculatus*) that are not controlled with a single application. Field trials were conducted in 2017 and 2018 to simulate failed control of waterhemp and Palmer amaranth following initial applications of glufosinate and fomesafen, and subsequently to determine optimal respray options for controlling escapes from the first application. Initial applications of glufosinate (450 g ai ha^{-1}) and fomesafen (280 g ai ha^{-1}) were made and follow-up applications of glufosinate at a high and low use rate (740 and 450 g ai ha^{-1}), fomesafen (450 g ai ha^{-1}), lactofen (220 g ai ha^{-1}), 2,4-D (1120 g ai ha^{-1}), and dicamba (560 g ai ha^{-1}) were made 3-5, 7, or 11 days after initial application. Efficacy of the sequential herbicide was quantified with visual assessments of control at 7, 14, and 21 days after the sequential herbicide treatment, and by counting new branches on five marked plants $plot^{-1}$ at 7 and 14 days after sequential herbicide treatment. Reduced height and branches after herbicide application indicates reduced plant fitness and competitiveness and is associated with high levels of control. Timing of sequential herbicide application resulted in differential levels of control for some herbicides. In waterhemp, glufosinate and lactofen applied 7 or 11 days after an initial application resulted in 4-13% greater control than when applied three days after the initial application. In Palmer amaranth, dicamba, lactofen, and 2,4-D applied seven days after initial application resulted in 4-8% greater control and 43-88% fewer branches than when applied 11 days after initial application. Some herbicides were more effective than others at controlling weed regrowth. In waterhemp, applications of 2,4-D resulted in 6-8% greater control compared to dicamba, while no differences were observed in Palmer amaranth. In both species, sequential applications of fomesafen resulted in 7-14 % greater control than lactofen. Glufosinate at the 740 g ha^{-1} provided the highest levels of control among species, timings, and initial herbicides tested. In the event of herbicide failure, high levels of control can be achieved, however, restrictions from the crop herbicide tolerance, label, or calendar date are likely to occur. This research can help growers and applicators to make the best decisions for making respray applications, but proper sprayer setup and diligent application should be used to avoid the situation wherever possible.

HINDERING HORSEWEED: AN INTEGRATED APPROACH FOR SOYBEANS IN KENTUCKY. Austin D. Sherman*; University of Kentucky, Lexington, KY (133)

Horseweed is prevalent in US soybean production systems. It is widely glyphosate-resistant, including in Kentucky. Horseweed can emerge in the fall, spring, and summer, necessitating extended periods of control. Research and experience show multiple methods of management to be a sustainable strategy in regards to weed control. Therefore, the objective of this study, conducted over two years (2016/17 and 2017/18), was to determine the best glyphosate-resistant horseweed management practices prior to soybeans from a fully-factorial combination of fall-planted cover crop (rye or none), fall-applied herbicide (saflufenacil or none), and spring-applied herbicide (dicamba, 2,4-D ester, or none). We hypothesized that the three-factor combination would result in the lowest horseweed numbers – existing plants would be killed by fall and spring burndown, and rye residue would inhibit emergence until soybean canopy closure. Rye was sown in late fall, with saflufenacil application the day after. Growth regulators were applied in mid-March 2017 and early-April 2018. Rye termination with glyphosate occurred two wk before soybean planting. Soybeans were planted on 38-cm rows in May; a postemergence (POST) application of glyphosate to target weeds other than the resistant horseweed occurred in 2018. Horseweed was counted before each treatment was applied, then roughly every two wk afterward until soybean canopy closure with a final count prior to harvest. Two permanent quadrats were staked in each plot and horseweeds were counted in the same area. Both years, saflufenacil was effective in reducing horseweed density by three wk after application. Where saflufenacil was not applied, the cover crop also reduced horseweed density. By spring, horseweed density was still lower following saflufenacil, though not with the cover crop. After cover crop termination in 2017, fewer horseweed plants were observed following the cover crop, regardless of whether herbicides were applied. Following cover crop termination in 2018, there were less horseweed plants where there was rye and a spring-applied herbicide. Prior to soybean harvest in 2017, there was more horseweed plants in plots with saflufenacil; this was observed earlier in the season in 2018. We hypothesize that the combination of reduced winter annual competition resulting from the fall saflufenacil application and reduced summer annual competition resulting from the POST glyphosate application resulted in increased horseweed pressure in this year. This also resulted in lower soybean yield in these treatments. In conclusion, for horseweed control in soybeans, a fall burn-down is not enough: a cover crop and a spring-applied herbicide are necessary, especially in years with spring emergence.

DIRECT COMPARISONS OF SENSITIVITY AND RESISTANCE TO PPO INHIBITORS IN WATERHEMP AND PALMER AMARANTH POPULATIONS. Kathryn Lillie*[1], Darci Giacomini[1], Patrick Tranel[2]; [1]University of Illinois, Urbana, IL, [2]University of Illinois, Urbana, IL (134)

Amaranthus tuberculatus was reported to be resistant to PPO-inhibiting herbicides in 2001, and it was the first weed to evolve resistance to these herbicides. The first known mechanism of PPO-inhibitor resistance involves the deletion of the amino acid glycine at the 210th position in PPX2 (dG210). Since *A. tuberculatus* first evolved this resistance, at least twelve other weed species have evolved resistance to PPO-inhibiting herbicides, including *A. palmeri*. The first documented case of PPO-inhibitor resistance in *A. palmeri* was in 2011, ten years after the first documented case of resistance to these herbicides in *A. tuberculatus*. The objectives of this study are to characterize the relative levels of resistance to PPO-inhibiting herbicides in *A. palmeri* and *A. tuberculatus* conferred specifically by the dG210 mutation, and to determine the selective advantage of resistance to PPO-inhibiting herbicides in *A. palmeri* relative to *A. tuberculatus*. Dose-response experiments were carried out on sensitive and resistant populations of both species at three different growth stages: pre-emergence, 8-10-cm, and 13-15-cm tall plants. The pre-emergence dose responses were with fomesafen and flumioxazin, and the postemergence dose responses were with fomesafen and lactofen. Additionally, lactofen and fomesafen were applied to six wild type populations of each species at three growth-reduction doses of 10%, 50%, and 90%, based on previous studies. Results from the postemergence dose responses show that wild type *A. palmeri* was more tolerant than wild type *A. tuberculatus* when sprayed at either timing, and wild type *A. palmeri* sprayed at a later timing was less sensitive than resistant *A. tuberculatus* sprayed at an early timing, suggesting that *A. palmeri* is more tolerant to PPO-inhibiting herbicides. These results help highlight the importance of making timely postemergence applications of PPO-inhibiting herbicides, as well as provide an explanation as to why *A. palmeri* took so much longer to evolve resistance to PPO-inhibiting herbicides relative to *A. tuberculatus*.

DO VARYING ANTIOXIDANT ENZYME LEVELS FOLLOWING A PPO HERBICIDE APPLICATION HELP EXPLAIN THE RESULTING VARIABLE HERBICIDE RESPONSE IN TALL WATERHEMP? Brent C. Mansfield*[1], Haozhen Nie[2], Yiwei Jiang[1], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]Purdue University, west lafayette, IN (135)

Reactive oxygen species (ROS) result from oxidative stress in plants. Over-accumulation of ROS in plants results in lipid peroxidation and is among the most destructive cellular processes in living organisms. The primary defense mechanisms in plants to detoxify ROS are enzymatic and non-enzymatic antioxidants. Although enhanced antioxidant enzyme activity is beneficial for plants enduring oxidative stress, these pathways also have negative implications for the efficacy of herbicides that generate ROS as part of the mode of action, such as protoporphyrinogen oxidase (PPO)-inhibitors. Greenhouse experiments have shown variable resistance ratio values in tall waterhemp populations resistant to PPO-inhibiting herbicides that contain the same target site mutation. Thus, a hypothesis was formed that enzymatic antioxidant activity in tall waterhemp resistant to PPO-inhibiting herbicides may contribute to the overall variability in herbicide response. Greenhouse experiments were conducted to measure basal levels of superoxide dismutase (SOD), ascorbate peroxidase (APX), catalase (CAT), and glutathione reductase (GR) in 20 tall waterhemp populations ranging in herbicide sensitivity from susceptible to resistant with variable resistance ratios to PPO-inhibiting herbicides. In addition, the change in SOD, CAT, APX, and GR over time following fomesafen treatment was also evaluated. Fomesafen was applied at 342 g ha^{-1} to 10 to 14 true-leaf tall waterhemp. Leaves of tall waterhemp plants from the fifth node and up were collected at 0, 3, 6, 9, 12, 24, and 36 hr after treatment (HAT) for determination of enzyme concentrations. Enzyme concentrations at basal levels were not specific to resistant or susceptible biotypes in tall waterhemp. However, tall waterhemp populations exhibited different APX, CAT, and GR concentrations at basal levels regardless of genotype. There were no differences in SOD concentrations at basal levels or across collection timings. Concentrations of APX and CAT were greater in resistant populations from 9 to 36 HAT. The concentration of GR was only higher in resistant populations at nine HAT. In conclusion, antioxidant enzyme activity appears to vary more at the population level and is not associated with PPO-resistant or -susceptible plants.

FOMESAFEN RESISTANCE IN *AMARANTHUS RETROFLEXUS*. Brent P. Murphy*[1], Mark Loux[2], Bruce A. Ackley[2], Patrick Tranel[3]; [1]University of Illinois, Urbana, IL, [2]The Ohio State University, Columbus, OH, [3]University of Illinois, Urbana, IL (137)

Amaranthus retroflexus L. is one of the most widely distributed agricultural weeds and is reported to cause severe crop losses. In comparison to other species such as *A. tuberculatus (Moq.) Sauer*, relatively few cases of herbicide resistance have been reported in *A. retroflexus*. Accessions of *A. retroflexus* collected in a 2016 Ohio herbicide resistance survey were assayed for resistance to the Group 14 herbicide fomesafen. Accession-specific, uniform survival was observed to 329 g ha^{-1} of fomesafen in initial screening. Dose-response analysis was conducted for the PPO-inhibitor fomesafen; the ALS-inhbititors imazethapyr, chlorimuron, and cloransulam; the PSII-inhibitors atrazine, diuron, and bromoxynil; and the EPSPS-inhibitor glyphosate. Dose-response analysis revealed a resistance factor of 2.2 between two accessions in response to fomesafen. Resistance to ALS-,PSII-, and EPSPS-inhibitors was not observed. Sequence analysis of the PPX2L gene revealed no previously characterized mutations, such as ΔGly210 or R128, within the resistant population. However, amino acid substitutions were identified that delimit the resistant and sensitive accessions. Functional validation of these substitutions using a model *Escherichia coli* system is underway.

REGIONAL PERSPECTIVE ON GRAIN SORGHUM YIELD LOSSES BECAUSE OF WEED INTERFERENCE. Anita Dille*[1], Nader Soltani[2], Peter H. Sikkema[2], Phillip Stahlman[3], Curtis R Thompson[1]; [1]Kansas State University, Manhattan, KS, [2]University of Guelph, Ridgetown, ON, [3]Kansas State University, Hays, KS (138)

Grain sorghum [*Sorghum bicolor* (L.)] is traditionally grown in the “Sorghum Belt” that extends from South Dakota to southern Texas and primarily on dryland ha. In 2017, farmers planted 2.3 million ha and harvested 4.5 billon kg of grain sorghum. Weeds are one of the most significant threats to grain sorghum production in this region. Losses in crop yield and quality due to weed interference, as well as costs of controlling weeds, which have a significant economic impact on crop production. Yield loss estimates were obtained from weed control studies conducted from 2007 to 2015 and were determined by comparing observations of grain sorghum yields between the weedy control plots and plots with greater than 95% weed control. Data were gathered from weed control reports and from researchers in Texas, Arkansas, Kansas, Nebraska, and South Dakota. At least 10 individual comparisons for each state were documented across the nine years, were averaged within a year, and averaged over the nine years. These percent yield loss values were used to determine total grain sorghum yield loss in kg ha^{-1} based on average grain sorghum yields for each state as well as current commodity prices for a given year as summarized by USDA-NASS. Annual yield losses were 60.3% in Texas, 39.5% in Arkansas, 32.8% in Kansas, 56.2% in Nebraska, and 50.1% in South Dakota. Averaged across 2007 to 2015, weed interference in grain sorghum caused 47.8% yield loss. Using an average grain sorghum price across 2007 to 2015 of US $7.83/cwt, farm gate value would be reduced by US $1,254 million annually if no weed management tactics were employed.

EVALUATION OF WATERHEMP POPULATIONS USING 2,4-D, DICAMBA, MESOTRIONE AND IMAZETHAPYR. Estefania G. Polli*[1], Rosa Soriano[1], Julia Maria Rodrigues[1], Kasey Schroeder[1], Jeffrey Golus[1], Bruno Canella Vieira[2], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (139)

Waterhemp (*Amaranthus tuberculatus* (Moq.) J. D. Sauer) is a summer annual broadleaf weed that is difficult to control and is present in most of the United States. This weed is a problematic species due to its abundant seed production, fast growth and a vast number of herbicide-resistant populations. In Nebraska, waterhemp populations resistant to glyphosate have been widely reported. Hence, the use of herbicides with alternative modes of action have become one of the most important tools to obtain weed control in problematic areas. Therefore, the objective of this study was to investigate the efficacy of late season applications of 2,4-D, dicamba, mesotrione, and imazethapyr on waterhemp populations. The study was conducted with a total of 79 populations of waterhemp collected in the crop production fields in 2013 and 2014 in Nebraska. Plants were grown under greenhouse conditions at the Pesticide Application Technology Laboratory, West Central Research and Extension Center in North Platte, Nebraska, between February and July of 2018. Plants (40-50 cm tall) were sprayed with a three nozzle Research Track Sprayer calibrated to deliver 187 L ha^{-1} with AIXR11004 nozzles at 276 kPa. Applications were made using discriminant doses of 2,4-D (1065 g ae ha^{-1}), dicamba (559 g ae ha^{-1}) , mesotrione (105 g ai ha-1) , and imazethapyr (70 g ai ha^{-1}). The study was conducted in two experimental runs in a Completely Randomized design with five replications. Visual estimations of injury were recorded 7, 14, 21 and 28 days after treatment (DAT). At 28 DAT the surviving plants above-ground biomass were harvested and oven-dried at 65 C to constant weight. Biomass data were subjected to analysis of variance in SAS software and treatment means were calculated using Fisher's least significant difference at a=0.05. The results showed 33.4% and 49.3% of the waterhemp populations were controlled satisfactorily (>90% control) by dicamba and 2,4-D, respectively. However, 63.3% and 93.4% of the populations had less than 50% control from mesotrione and imazethapyr, respectively. Thus, these two herbicides did not provide satisfactory control on waterhemp populations from Nebraska. Further studies investigating the distribution and frequency of 2,4-D-, HPPD-inhibitor-, and ALS-inhibitor-herbicide resistances on waterhemp from Nebraska is necessary as biotypes resistant to those herbicides have been reported in the state.

IMPACTS OF DROUGHT TOLERANT CORN HYBRID COMPETITION AND WATER STRESS ON WEED COMMUNITY COMPOSITION AND CORN PERFORMANCE. Erin E. Burns*, Maninder Singh; Michigan State University, East Lansing, MI (140)

Nearly all crop production is impacted by drought. Corn yield losses can occur during years when in-season rainfall is limited during pollination and grain fill. Future climate scenarios for the Great Lakes Region predict more precipitation in heavy rainfall events, leaving more days during the growing season that have little or no precipitation, polarizing the wet and dry periods. To address this future climate scenario a field study was conducted in East Lansing, MI in 2018 evaluating the impacts of reduced precipitation and weed competition on drought- and non-drought-tolerant corn hybrid performance. The study was conducted as a split-plot randomized block design with four replications. Whole plots were assigned to a corn hybrid with and without the Genuity® DroughtGard® trait. Sub-plots were factorial combinations of one of three weed densities (weed-free, 50% weeds, 100% weeds) and presence or absence of precipitation. Rainout shelters were designed to impose 50% rainfall interception. Corn plant height, stage, and weed density were measured monthly in early July, August and September. At October harvest, the dominant corn ear from 10 plants $plot^{-1}$ were individually harvested for yield component analysis. Dominant weed species included: common lambsquarters (*Chenopodium album*), Powell amaranth (*Amaranthus powellii*), velvetleaf (*Abutilon theophrasti*), and green foxtail (*Setaria viridis*). Weed density was not impacted by precipitation level or corn hybrid. Corn height in July and August was reduced in the 50% and 100% weed densities treatments when precipitation was 50% that of ambient precipitation. Hybrids containing the drought guard trait were taller in July and August compared with hybrids without the trait under ambient precipitation levels; however under reduced precipitation there was no difference in plant height. By September, corn was shorter only in the 100% weed density treatment when compared to the weed-free and 50% weedy treatment under ambient precipitation. Regardless of weed pressure, corn plants of both hybrids were shorter under reduced precipitation levels compared to the weed-free ambient precipitation treatment. Regardless of weed density, corn hybrids containing the drought trait were shorter compared to hybrids without the trait in the 50% and weed-free treatments. Weeds reduced corn yield by 6% when not controlled compared with the weed-free control ($p = 0.047$). Reduced precipitation reduced corn yield by 8% ($p = 0.0006$), when averaged over hybrids and weed densities. Corn hybrids without the drought-tolerant trait yielded 13% more than hybrids with the drought-tolerant trait, when averaged across precipitation level and weed density ($p < 0.0001$). Overall, results from year one of this study highlight drought-tolerant corn hybrids are sensitive to reduced precipitation levels and that this response is modified by weed density.

JOHNSONGRASS (SORGHUM HALEPENSE) DEMOGRAPHY IN NEBRASKA. Don G. Treptow*[1], Rodrigo Werle[2], Amit Jhala[3], Melinda Yerka[3], Brigitte Tenhumberg[1], John Lindquist[4]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska, Lincoln, NE (141)

Johnsongrass is a troublesome perennial weed that is related to and capable of interbreeding with grain sorghum. Therefore, traits that improve sorghum may also become introgressed in Johnsongrass populations. Understanding Johnsongrass demography is necessary for predicting its long-term population dynamics in agroecosystems. One of our goals is to develop a risk assessment model to assess the impact of desired sorghum crop traits and their potential introgression in weedy sorghums. Such model requires information on Johnsongrass demographic parameters. A field experiment was conducted at the UNL – Eastern Nebraska Research and Extension Center near Mead, NE and at the UNL – Havelock Farm, Lincoln, NE from 2015 through 2018. The experiment was conducted using a two-way factorial on a randomized complete block design with four replications. Johnsongrass population and herbicide treatment were the two treatment factors. Two Johnsongrass populations were used which included ALS-susceptible and ALS-resistant Johnsongrass. Herbicide treatments included three different herbicide programs along with a no herbicide control. Replicated 2 by 2 m plots were established at each site in the summer of 2015 by transplanting 16 Johnsongrass plants in a uniform pattern. Over the course of the study, above- and below-ground demographic data were collected, including: number of Johnsongrass culms originating from rhizomes, number of panicles and seeds panicle^{-1}, and viability of newly produced seed. Soil cores were collected in the spring and fall from each plot to quantify the number of rhizomes, number of buds rhizome^{-1}, and bud viability. In addition, freshly produced seeds and rhizomes were buried in the adjacent part of the field and recovered after various lengths of time. Results were used to estimate Johnsongrass seedling and sprout survival, viable seed production, fresh rhizome and bud production and bud viability, seed and bud overwinter and within season survival, fraction of seeds and buds producing seedlings and sprouts, and the influence of different herbicides on these parameters. Estimated demographic parameters will inform a risk-assessment model for simulating gene flow and Johnsongrass population dynamics to understand ALS-resistance evolution under different crop rotations and herbicide programs.

EVALUATION OF CANOLA AND CEREAL RYE TERMINATION TIMING ON CROP YIELD AND SUMMER ANNUAL WEED CONTROL IN THE EASTERN CORNBELT. Stephanie DeSimini*, William G. Johnson; Purdue University, West Lafayette, IN (142)

The recent interest in cover crops as an addition to corn and soybean production systems in the Midwest has led to a greater need for research into the role of cover crops in weed suppression and the influence of termination timing on crop yield. Previous research has shown that certain cover crop species can reduce cash crop yields if not terminated successfully prior to a desired cash crop planting. Field experiments were initiated in 2016 and repeated in 2017 to evaluate summer annual weed suppression, and to quantify how a late termination of cover crops can effect corn and soybean yield. There are many varieties of cover crops available in the Midwest, and we selected cereal rye (*Secale cereale*) and canola (*Brassica napus*) for their rapidly accumulating aboveground biomass, potential allelopathy, and winter hardiness. Cereal rye and canola were planted on Sept 21 and Sept 22 in 2016 and 2017 respectively at the Throckmorton Purdue Agricultural Center (TPAC) near West Lafayette, Indiana. Herbicide treatments were applied the following spring around our cash crop planting dates. Early cover crop termination was two wk before planting (2WBP) our desired cash crop, and late termination was two wk after planting (2WAP). Corn and soybeans were planted on May 10 in 2017 and on May 15 in 2018. Summer annual weed densities and biomass samples were collected at each termination timing. Corn and soybeans were harvested on October 31 and October

23 in 2017 and 2018, respectively. As for weed control, there were no differences in weed densities between cover crop treatments, but there was a reduction in weed biomass. Weed biomass collected in plots with cereal rye residue had an average of 88% (2WBP) and 89% (2WAP) less biomass than fallow treatments. Cereal rye reduced corn yield at the late termination timing (2WAP) in both 2017 and 2018 compared to fallow treatments (28 and 36% reduction, respectively). There were no corn yield differences between canola and fallow treatments in both 2017 and 2018. Soybean yield was not different between any cover crop treatments in 2018. In 2017 however, cereal rye terminated 2WAP reduced yield by 13% compared to cereal rye terminated 2WBP. Canola terminated 2WAP resulted in 18% yield reduction compared to canola terminated 2WBP. These results indicate that cover crop termination timing can play a role in weed suppression and selection of an appropriate cover crop terminated properly will not reduce corn or soybean yield. Cover crops can be a potential addition to weed management strategies, when used in tandem with a good herbicide program.

EFFECT OF WINTER ANNUAL COVER CROP PLANTING DATE AND HERBICIDE PROGRAM ON WEED SUPPRESSION IN CORN-SOYBEAN CROPPING SYSTEMS. Joshua S. Wehrbein*, Christopher Proctor; University of Nebraska-Lincoln, Lincoln, NE (143)

Cover crops have been shown to be effective at suppressing weeds in many different agricultural systems, however, results are not always consistent and often depend upon several variables including environmental factors, weed species present, and management practices used. The objective of this study was to determine the effect of cover crop planting date, termination date, and herbicide program on winter and summer annual weed suppression in a corn (*Zea mays* L.) and soybean (*Glycine max* L.) cropping system. Field trials were conducted in 2017/2018 at the University of Nebraska-Lincoln Havelock Research Farm near Lincoln, NE. A cereal rye (*Secale cereal* L.) and oat (*Avena sativa* L.) mixture was planted on four different dates following soybean harvest and was terminated on two different dates prior to corn planting. Herbicide treatments included: fall burndown + spring preemergence (PRE) + postemergence (POST), spring PRE + POST, and POST. Weed biomass, density, and control data were collected. Results from year one of the study indicate that cover crop planting and termination date had no effect on weed biomass or weed density, likely due to low cover crop biomass production. Herbicide treatments containing a fall burndown did not reduce weed density or biomass more than spring PRE-treatments. Fall burndown and spring PRE-treatments provided greater percent weed control than POST only treatments three wk after the POST application. These results indicate that cover crops may not always be successful at providing effective weed suppression but managing weeds when they are small in size and use of spring residual or fall applied herbicides may be necessary to provide adequate weed control for the duration of the growing season.

BENEFITS OF MESOTRIONE IN THE RESIDUAL CONTROL OF ALS-RESISTANT GIANT RAGWEED IN MGI SOYBEAN. Benjamin C. Westrich*, Brent C. Mansfield, Bryan G. Young; Purdue University, West Lafayette, IN (145)

Residual control of giant ragweed (*Ambrosia trifida*) is difficult in soybean production, especially in the presence of ALS-resistance. Pre-emergent (PRE) applications of mesotrione may help to control populations of ALS-resistant giant ragweed in MGI (SYHT0H2) soybean and could reduce selection pressure for ALS-resistant biotypes. Therefore, field experiments were conducted to evaluate the resulting weed control of PRE applications of mesotrione alone and in combination with S-metolachlor, metribuzin, and cloransulam in resistant soybean. Mesotrione applied alone resulted in 86% control of giant ragweed at the low-resistance location (15% frequency of ALS-resistant individuals) at 21 days after application (DAA), which was greater than both S-metolachlor and metribuzin (<19%) and similar to cloransulam (73%). By 42 DAA, herbicide treatments including mesotrione as well as the standard flumioxazin + pyroxasulfone + chlorimuron resulted in greater control than other treatments. At the high-resistance location (79% frequency of ALS-resistant individuals), treatments containing mesotrione were the only treatments that provided the greatest level of giant ragweed control (> 90%) at both the 21 and 42 DAA evaluations. The standard herbicide comparison treatments that contained either cloransulam or chlorimuron failed to provide a high level of residual control by 42 DAA at the high-resistance location. The inclusion of additional herbicide site of action groups with mesotrione did not increase giant ragweed control beyond mesotrione alone at either timing or location. Giant ragweed tissue samples were collected at 21 DAA from plots that were sprayed with an ALS-inhibitor, and a TaqMan® SNP genotyping assay designed to amplify the Trp574Leu mutation was used in qPCR analysis to quantify the frequency of ALS-resistance.

At the low-resistance location, more than 95% of giant ragweed plants surviving a PRE application of cloransulam were found to be ALS-resistant, compared with 15% in non-treated plots. When mesotrione was applied with cloransulam, 54% of the surviving plants were found to be ALS resistant. Overall, results from this study indicate that potential PRE applications of mesotrione in SYHT0H2 soybean could lead to improved control of giant ragweed and reduced selection pressure for ALS resistance.

IMPACT OF PPO AND PSII SOIL-APPLIED HERBICIDES ON EARLY SEASON SOYBEAN DEVELOPMENT AND GRAIN YIELD. Nikola Arsenijevic*[1], Matheus de-Avellar[2], Alexandre Tonon Rosa[3], Gustavo De Souza Vieira[1], Liberty E. Butts[1], Rodrigo Werle[4]; [1]University of Nebraska Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Wisconsin-Madison, Madison, WI (146)

The use of pre-emergence (PRE) soil-applied herbicides has become crucial for proper weed management in soybeans across the US. The use of PSII- and/or PPO-inhibitor soil-applied soybean herbicides may, under certain circumstances, result in early season crop injury. A field study was conducted in North Platte and Brule, southwest Nebraska, during the 2016 and 2017 growing seasons with the objective to evaluate the impact of soil-applied herbicides metribuzin and sulfentrazone on early season development, final plant stand and grain yield of 22 varieties adapted to the north central region. Herbicide treatments consisted of metribuzin (560 g ai ha^{-1}) and sulfentrazone (280 g ai ha^{-1}) applied within three days from planting using a backpack sprayer calibrated to deliver 94 L ha^{-1}; no herbicide control was also included as a treatment. The study was conducted on a randomized complete block design with four replications. Experimental units were three m wide (four rows) by seven m long and were kept weed-free season long by hoeing and hand-pulling emerged weeds. When soybeans reached the V2 growth stage, quadrats (0.76 x 0.76 m) were randomly placed twice in the second and third rows of each experimental unit and four pictures taken; pictures were processed using the Canopeo app, which estimates live green vegetation (%). Green vegetation coverage data were used as indicator of early-season soybean growth. When soybeans reached maturity, one m of soybean row from rows two and three of each experimental unit were manually harvested, established plants enumerated, grain threshed and yield estimated (g 2 m of row^{-1} corrected to 13% moisture). According to results, there was no interaction between herbicide treatment and soybean variety for the response variables evaluated herein; thus, main effects were evaluated. Sulfentrazone reduced early season soybean growth (e.g., reduced live green vegetation) and final plant stand, whereas metribuzin had no impact on these parameters when compared to no herbicide treatment. However, the herbicide treatments used herein did not reduce grain yield. Early season growth, final plant stand and final yield were variety dependent. These results support the rationale that the weed control provided by PREs outweigh any potential concern related to early-season crop injury (assuming herbicides are applied according to the label).

EVALUATION OF TRIFLUDIMOXAZIN ALONE AND IN COMBINATION WITH SAFLUFENACIL FOR SOIL-RESIDUAL AND FOLIAR CONTROL OF PPO INHIBITOR-RESISTANT TALL WATERHEMP. Nicholas R. Steppig*[1], Samuel D. Willingham[2], Bryan G. Young[1]; [1]Purdue University, West Lafayette, IN, [2]BASF, Seymour, IL (147)

With the continued evolution of Amaranthus biotypes which are resistant to postemergence (POST) applications of ALS-inhibitors, glyphosate, and PPO-inhibitors (Groups 2, 9, and 14, respectively), use of both effective pre-emergence (PRE) and POST herbicides is recommended as a Best Management Practice. Furthermore, the relatively low-level resistance imparted by these target-site mutations for Group 14 resistance allows for residual control from certain PPO-inhibiting herbicides. Trifludimoxazin is a new PPO-inhibiting herbicide currently under development by BASF Corporation, which has been reported to have both PRE and POST activity on Amaranthus weeds. However, little data exists describing the extent of foliar activity or length of residual control of trifludimoxazin on Amaranthus. Field trials were conducted at two locations in Indiana, at the Meigs Horticulture Research Farm (Meigs) near Lafayette, Indiana, and at the Davis Purdue Agricultural Center (DPAC), near Farmland, Indiana, in 2017 and 2018. The native tall waterhemp populations contained <3% and >30% PPO-resistant individuals at Meigs and DPAC, respectively. In PRE trials, applications of trifludimoxazin (0, 12.5, 25, and 50 g ha^{-1}) were made alone and in combination with saflufenacil (0, 25, and 50 g ha^{-1}) to non-crop field sites. In POST trials, trifludimoxazin was applied alone (0, 6.25, 12.5, and 25 g ha^{-1}), and in combination with saflufenacil (25 and 50 g ha^{-1}) to tall waterhemp at 5 to 10 cm in height. At 4WAA, residual control of tall waterhemp ranged from 36 to 95%, 57 to 94%, and 78 to 98% in treatments containing trifludimoxazin at 12.5, 25, and 50 g ha^{-1}, respectively. Tall waterhemp control at 4WAA ranged from 55 to 96% and 89 to 96% in treatments containing only saflufenacil at 25 and 50 g ha^{-1}, respectively. With the exception of 12.5 g ha^{-1} trifludimoxazin + 25 g ha^{-1} saflufenacil, all combinations of the two herbicides provided >93% tall waterhemp control at 4WAA. POST control of tall waterhemp at 28DAA was >90% in treatments utilizing 12.5 and 25 g ha^{-1} of trifludimoxazin at both locations, across both years. Therefore, trifludimoxazin has effective foliar efficacy on tall waterhemp populations containing biotypes resistant to Group 14 herbicides. Furthermore, trifludimoxazin applied PRE exhibited effective, albeit variable, residual control alone of these same populations with overall efficacy enhanced by the combination with saflufenacil.

DO PLANNED POSTEMERGENCE HERBICIDES INTERACT WITH SOYBEAN RESPONSE TO OFF-TARGET DICAMBA EXPOSURE? Cade Hayden*, Bryan G. Young; Purdue University, West Lafayette, IN (148)

Adoption of dicamba-resistant soybean has led to an increased amount of dicamba applied and a longer period throughout the growing season for applications to occur. The shift to this technology has led to an increased potential for dicamba-sensitive soybean exposure to off-target movement of dicamba through tank contamination or drift. Dicamba injury to sensitive soybean has been a concern for growers throughout the 2017 and 2018 growing seasons, even with improved formulations and significant label restrictions for the application of dicamba. Soybean injury may also occur from labeled postemergence (POST) herbicide applications for broadleaf weed management. Soybean injury from these planned POST herbicides may influence the extent of soybean injury from accidental dicamba exposure. Thus, a field experiment was conducted in 2017 and 2018 to evaluate the combined influence of dicamba exposure before or after planned POST herbicides on dicamba-sensitive soybean. Glyphosate, chlorimuron, lactofen, lactofen plus acetochlor, and lactofen plus 2,4-DB were applied at both at the V3 and R1 growth stages of soybean. A reduced rate of dicamba (5.6 g ae ha^{-1}) was applied at R1 following the planned POST herbicides applied at V3, or dicamba was applied at V3 prior to the planned POST herbicides applied at R1. This reduced rate was intended to simulate a dose representing off-target exposure to soybeans. The application of lactofen plus 2,4-DB prior to dicamba exposure increased soybean injury compared to dicamba exposure alone at the R1 growth stage. Other planned POST herbicide applications had no influence on the soybean injury that developed from dicamba exposure at the R1 growth stage. The exposure of soybean to dicamba at the R1 growth stage had the greatest impact on reducing soybean plant height and grain yield. Thus, the interaction of the planned POST herbicide and application timing influenced the level of soybean injury, but the same interaction was not evident for plant height and seed yield at harvest. These findings are consistent with other research that has documented that soybean yield loss correlates with reductions in plant height to a greater extent than visual soybean injury. Furthermore, the planned POST herbicides had a relatively minor role in determining soybean yield response compared to the influence of dicamba exposure.

WATERHEMP MANAGEMENT IN WEST CENTRAL OHIO. Jeff M. Stachler*; The Ohio State University, Wapakoneta, OH (149)

Waterhemp is becoming more prevalent in Ohio, especially West Central Ohio. In Auglaize County, Ohio waterhemp was reported to be present in 21% of soybean fields at harvest time in 2015. By 2018, waterhemp was present in 51% of soybean fields at harvest time. Therefore on-farm small plot research was conducted in Auglaize County in 2017 and 2018 to demonstrate how to manage waterhemp in glufosinate- and dicamba-resistant soybean. Two trials were established in 2017 and 2018, one in glufosinate-resistant soybean and the other in dicamba-resistant soybean. The first two trials had a similar design. The one glufosinate-resistant trial investigated the application of no residual herbicide, flumioxazin plus chlorimuron, flumioxozin plus chlorimuron plus metribuzin, and flumioxazin plus chlorimuron plus pyroxasulfone applied pre-emergence (PRE) and flumioxazin plus chlorimuron followed by pyroxasulfone applied postemergence (POST). Glufosinate was applied POST at 7.6- to 10.2-cm tall waterhemp and 15.2 to 20.3 cm waterhemp following each of these residual herbicides. The dicamba-resistant trial investigated applications of the same residual herbicides. In this trial glyphosate, glyphosate plus fomesafen and glyphosate plus dicamba were applied POST to 7.6- to 10.2-cm tall waterhemp and 15.2 to 20.3 cm waterhemp following each residual herbicide. Combined over years there was no difference between the four residual herbicides at the time of the POST. Five wk after the POST the flumioxazine plus chlorimuron followed by pyroxosulfone, the flumioxoxazine plus chlorimuron plus pyroxosulfone, and the flumioxozin plus chlorimuron plus metribuzin provided the most effective control of waterhemp. There was no difference in the timing of the glufosinate application. The dicamba-resistant trial could not be combined over years due to glyphosate not being applied at both timings in 2017. In 2017 there was no difference in the control of waterhemp at the time of the POST application timing. In 2018, the flumioxozin plus chlorimuron plus pyroxasulfone controlled more waterhemp than the other residual herbicides followed by flumioxazin plus chlorimuron plus metribuzin. At five wk after the POST in 2017 there was still no difference in the control between the four different residual herbicides. In 2018, flumioxazin plus chlorimuron plus pyroxasulfon controlled the most waterhemp. In 2017, there was no difference between the application of fomesafen or dicamba. In 2018 dicamba had the greatest control of waterhemp. In both years there was no difference in the timing of the POST. The more effective the residual herbicide at the time of the postemergence herbicide, the more effective the control at the end of the season following the application of an effective POST.

UTILIZING CEREAL RYE AND CRIMSON CLOVER FOR WEED SUPPRESSION WITHIN, AND OUTSIDE OF, BUFFER AREAS IN DICAMBA AND 2,4-D RESISTANT SOYBEANS. Connor L. Hodgskiss*, William G. Johnson; Purdue University, West Lafayette, IN (150)

The development of soybean varieties that are tolerant to dicamba and 2,4-D have allowed for synthetic auxins to be used in soybean productions systems. Synthetic auxins control problematic broadleaf species that have evolved herbicide resistance to glyphosate and other active ingredients. The increase in dicamba use has caused issues due to off-target movement to sensitive areas. To reduce off-target movement, buffer areas are required between sprayed areas and downwind sensitive areas. Therefore, other methods of weed control will be needed in buffer areas where auxins are not permitted to control herbicide-resistant weeds. Use of cover crops as a source of weed suppression could be an important tool in these buffer areas. This research was conducted at three research sites in Indiana in 2018, the Throckmorton Purdue Agricultural Center (TPAC), South East Purdue Agricultural Center (SEPAC), and the Davis Purdue Agricultural Center (DPAC). Cereal rye, crimson clover and an 80/20 mixture of the two were evaluated for weed suppression. Cover crops were terminated two wk before soybean planting, at planting, and two wk after planting using three different herbicide strategies: glyphosate (1.28 kg ha^{-1}) alone, glyphosate in combination with dicamba (0.57 kg ha^{-1}) or 2,4-D (1.08 kg ha^{-1}), and glyphosate + 2,4-D/dicamba + a residual herbicide. Residual herbicides varied by site depending on weed pressure present. Early season weed control was similar for cereal rye and the mixture across termination timings and had at least 80% less weed biomass present compared to crimson clover. Weed control prior to a postemergence (POST) application at the SEPAC location showed that using crimson clover to suppress weeds was inconsistent, as weed biomass ranging from 1.27 g m^{-2} to 57.5 g m^{-2}, where cereal rye and the rye/clover mixture were more consistent with 0.06 g m^{-2} to 4.3 g m^{-2}. Cereal rye and the mixture controlled weed biomass with no differences between the three termination timings. Soybean yield was reduced as termination timing of the cover crop was delayed, terminating two wk after planting resulted in at least a 23% reduction in yield compared to the two wk before planting termination. This research indicates that cereal rye and an 80/20 mixture of cereal rye and crimson clover reduced weed biomass similarly regardless of termination timing evaluated. Therefore, terminating two wk before planting while using a cereal rye or 80/20 cereal rye/clover mixture will result in similar weed control and minimize any negative impacts on soybean yield.

INVESTIGATIONS OF THE EFFECTS OF SOIL PH ON THE VOLATILITY OF DICAMBA FORMULATIONS. Eric G. Oseland*, Mandy Bish, Kevin W Bradley; University of Missouri, Columbia, MO (151)

An evaluation of application parameters surrounding dicamba applications has suggested low soil pH may increase the volatility potential of dicamba formulations. Two identical field experiments were conducted in Columbia, Missouri in 2018 to determine if low soil pH increases the volatility of various dicamba formulations. The experiments were designed as a factorial in a randomized complete block. Non-dicamba tolerant soybeans were planted and plastic low-tunnels were utilized to cover two rows of soybeans for a length of six m in each plot. Soil pH was adjusted using aluminum sulfate and hydrolyzed lime resulting in soil pH values of 4.3, 5.5, 6.8, 7.7, and 8.3. Applications of dicamba were applied to greenhouse flats filled with 4.5 kg of pH-adjusted soil. Applications were made at a location geographically separate from the field trial and flats were transported by open vehicle to the field where they were placed in the center of each low tunnel between the soybean rows. Dicamba formulations used in the experiment included the diglycolamine (DGA; Clarity), N,N-Bis-(3-Aminopropyl)

Methylamine (BAPMA; Engenia), diglycolamine with Vapor Grip (DGA with VaporGrip; Xtendimax), and choline salt (experimental Corteva formulation). Each flat was treated with 1.12 kg ae ha^{-1} of dicamba. A non-treated control was included for each soil pH. At 72 hours after trial establishment, the experiment was terminated and soil and tunnels were removed from the field site. At 14 days after trial termination, visual soybean injury estimates were determined using the scale previously established by Behrens and Lueschen (1979). Data were analyzed using the PROC GLIMMIX procedure in SAS. In both experiments, soybean injury as a result of dicamba vapor movement increased in severity as soil pH levels decreased. Treatments including dicamba DGA with VaporGrip and the BAPMA formulations damaged soybean at similar levels as the DGA dicamba formulation when the soil pH was 4.3 and 5.3. The DGA with VaporGrip and BAPMA formulations also resulted in higher overall soybean injury when compared to the choline salt across all soil pH treatments. The choline salt and non-treated control resulted in similar levels of soybean injury at soil pH levels of 6.8, 7.7, and 8.3. The results of these experiments suggest that acidic soil pH conditions may contribute to the potential for an application of dicamba to move off-target. Further examination of the effect soil pH has on dicamba volatility and validation of the results of these field studies will take place in 2019 in a controlled environment.

WATERHEMP RESISTANT TO FOUR HERBICIDE SITES OF ACTION IN NEBRASKA: CONFIRMATION AND MECHANISM OF RESISTANCE. Debalin Sarangi*[1], Trey Stephens[2], Abigail Barker[3], Eric L. Patterson[3], Todd Gaines[3], Amit Jhala[2]; [1]Texas A&M University, College Station, TX, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Colorado State University, Fort Collins, CO (152)

Waterhemp is the most problematic weed in corn and soybean production fields in Nebraska. A waterhemp biotype (designated as NER) from Saunders County, Nebraska, survived the postemergence (POST) application of fomesafen at a labeled rate. Whole-plant dose-response bioassays were conducted in 2017 to quantify the level of resistance to POST-applied protoporphyrinogen oxidase (PPO)-inhibiting herbicides (acifluorfen, fomesafen, and lactofen). Mechanism of PPO-inhibiting herbicide resistance in NER biotype was also evaluated. Two known PPO inhibitor-sensitive waterhemp biotypes (S1 and S2) from Nebraska and one confirmed resistant biotype (ILR) from Illinois were included for comparison. Experiments were also conducted to determine if the NER biotype was multiple resistant to acetolactate synthase (ALS)-, 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)-, and photosystem II (PS II)-inhibiting herbicides. The dose-response bioassay revealed that NER biotype was 4- to 5-fold resistant to acifluorfen, 3- to 6-fold resistant to fomesafen, and 5- to 6-fold resistant to lactofen in comparison with S1 and S2. A Kompetitive Allele Specific PCR (KASP) assay identified that ΔG210 mutation (deletion of a codon) in the PPX2L gene conferred the PPO-inhibitor resistance in waterhemp. The results of this experiment revealed that NER biotype was multiple-resistant to ALS inhibitors (chlorimuron-ethyl and imazethapyr), EPSPS inhibitor (glyphosate), and PS II inhibitor (atrazine). Glufosinate, 2,4-D choline plus glyphosate, and dicamba applied at labeled rate resulted in $\geq 98\%$ control of NER biotype. Waterhemp is the first weed species in Nebraska showing resistance to four herbicide sites of action; therefore, no POST herbicide options are available for effective control of NER biotype in glyphosate-resistant soybean.

EVALUATION OF THE INFLUENCE OF DICAMBA EXPOSURE ON CANOPY CLOSURE OF GLUFOSINATE-RESISTANT SOYBEAN. Zachary K. Perry*[1], Madison D. Kramer[1], Travis R. Legleiter[2]; [1]University of Kentucky, Lexington, KY, [2]University of Kentucky, Princeton, KY (153)

Dicamba-resistant soybean along with lower volatility dicamba formulations have been introduced in an attempt to control herbicide-resistant weeds such as *Amaranthus palmeri*. This introduction has increased the amount of dicamba being applied later in the growing season increasing the prevalence of dicamba off-target movement. Off-target movement of dicamba caused over one million ha of soybean damage nationwide in 2017 and 2018. The objectives of this experiment were to evaluate the influence of timing and dosage of dicamba exposure on soybean canopy development and evaluate if canopy closure delays influence late season *Amaranthus palmeri* emergence. In the following experiment, dicamba damage was mimicked by applying low rates of dicamba directly on soybeans at rates of 0.5 g ae ha^{-1}, 1 g ae ha^{-1} and 5 g ae ha^{-1} dicamba. Trial design was randomized complete block design with four replications at three locations. The UKREC site in Caldwell County was maintained weed free, Trigg County had a population of Palmer amaranth, and Webster County had a population of waterhemp, although the density was too low to evaluate. Crop injury and trifoliate damage was evaluated at all three sites. Canopy development was assessed using Canopeo photos at the UKREC site in Caldwell

County location. Palmer amaranth counts were taken at the Trigg County location in a pre-determined 3.5 m^2 area within the plot. Soybean exposed to dicamba early in the month of June express the greatest damage at 21 DAT, while late June and early July exposures expressed greatest injury at 28 DAT. Reduction in canopy development as compared to a non-exposed treatment was greater in exposures in July than in June. Palmer counts showed that a greater amount of additional palmer emergence as compare to an untreated plot occurred when exposure to dicamba occurred in mid-June.

MANAGING PPO-RESISTANT *AMARANTHUS* SP. IN ROUNDUP READY 2 XTEND® SOYBEANS. Neha Rana*[1], Rod Stevenson[2], Ryan E. Rapp[3], Blake R. Barlow[4], Alejandro Perez-Jones[1], Chenxi Wu[5]; [1]Bayer CropScience, Chesterfield, MO, [2]Bayer CropScience, plainwell, MI, [3]Bayer CropScience, Mitchell, SD, [4]Bayer CropScience, Columbia, MO, [5]Bayer CropScience, Urbana, IL (154)

Glyphosate-resistant Amaranthus species was detected in the mid 2000's and since then growers have relied upon protoporphyrinogen oxidase- (PPO) inhibitor herbicides for weed control in soybean and cotton. PPO-inhibitor-resistance in Amaranthus species was recently detected when applied pre and post-emergent. With the heavy reliance upon PPO-inhibitor chemistry and glufosinate in soybean weed control systems, XtendiMax® herbicide with VaporGrip® Technology provides an effective site of action (SOA) to control PPO-inhibitor-resistant weed species. In 2018, fifteen field trials were conducted in IA, IN, IL, AR, MO, TN, KY, NE, MN, MD, and NC to evaluate control of PPO-inhibitor-resistant weed species using one or more effective SOA applied pre-emergence (PRE) followed by postemergence (POST) applications. Twelve of these trials were conducted with university academics on sites with confirmed PPO-inhibitor-resistant weed populations. PPO-inhibiting herbicides alone provided ≤ 50% control of PPO-inhibitor-resistant weed species five wk after PRE treatment. Adding another effective SOA to the PPO-inhibiting herbicides PRE followed by a POST application of XtendiMax® herbicide with VaporGrip® Technology + Roundup PowerMAX® herbicide + Intact™ provided greater (≥ 96%) control of PPO-inhibitor-resistant waterhemp (*Amaranthus tuberculatus*) compared to PPO-inhibiting herbicides applied PRE alone followed by XtendiMax® herbicide with VaporGrip® Technology + Roundup PowerMAX® herbicide + Intact™ 21 days after treatment.

CRITICAL PERIOD OF PARMER AMARANTH REMOVAL AFFECTED BY PRE-EMERGENCE HERBICIDES IN DICAMBA-RESISTANT SOYBEAN. Jose H. Scarparo de Sanctis*[1], Stevan Knezevic[2], Vipan Kumar[3], Amit Jhala[4]; [1]Universito of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Wayne, NE, [3]Kansas State University, Hays, KS, [4]University of Nebraska-Lincoln, Lincoln, NE (155)

The continuous and repeated use of single site of action herbicides for weed control in last two decades has resulted in the evolution of herbicide-resistant weeds in different US states including glyphosate-resistant (GR) Palmer amaranth in Nebraska. Pre-emergence (PRE) herbicides are an important component of herbicides programs employed for weed management and most growers do not acknowledge the importance of PREs and avoid their application to reduce the cost of production relying only on postemergence (POST) herbicides for weed control. A field study was conducted in 2018 at the grower's farm confirmed with the presence of GR Palmer amaranth at Carleton, NE to evaluate how timing of weed removal and PRE herbicides application effect growth and yield of dicamba/glyphosate-tolerant soybean. The study was arranged in a split-plot design with PRE herbicide treatments as the main factor and seven Palmer amaranth removal timings as split plot. Herbicide treatments included no PRE and two different PRE herbicides: flumioxazin at 107 g ai ha^{-1} and flumioxazin + pyroxasulfone pre-mixture at 160 g ha^{-1} tank-mixture with metribuzin at 315 g ha^{-1}. GR Palmer amaranth was the dominant weed species in the field and it was allowed to coexist with the soybean crop until V1, V3, V6, R2, or R5 soybeans growth stages, and then removed from the plots at those soybean growth stages. A weed free and weedy check was also included along with the soybean weed removal stages. The above-mentioned soybean growth stages corresponded to 15, 25, 35, 40, and 70 days after crop emergence. Palmer amaranth growth parameters such as plant height, density and biomass were recorded at each removal timing, and soybean growth parameters such as plant stand, pod count, seed weight, and yield were recorded during harvest. During each removal timing, plots were sprayed with dicamba at 560 g ha^{-1} and kept free of weeds by hoeing throughout the season. The use of PRE reduced the early season competition with weeds and pushed the 5% yields loss threshold to later growth stages when compared to no-PRE. The critical period of weed removal for no PRE occurred at V1 soybean growth stage; however, for flumioxazin + pyroxasulfone + metribuzin and flumioxazin, the 5% yield loss occurred at V2 and V3 soybean stage, respectively. Moreover, no PRE treatments showed an increased yield loss when compared to PRE applications, especially in later removal timings. The results from this study suggest that the use of PREs can postpone the critical time for Palmer amaranth removal to later soybean growth stages, allowing the crop to grow with less weed competition in the early stages.

CONTROL OF TWO *AMARANTHUS* SPECIES IN A SOYBEAN VARIETY TOLERANT TO GLYPHOSATE, GLUFOSINATE, AND DICAMBA. Travis R. Legleiter*[1], J D Green[2]; [1]University of Kentucky, Princeton, KY, [2]University of Kentucky, Lexington, KY (156)

Glyphosate-resistant *Amaranthus tuberculatus* and *Amaranthus palmeri* are wide spread across the state of Kentucky and remain the predominate weed problem for many Kentucky soybean producers. In addition to wide spread glyphosate resistance, PPO-inhibitor resistance has now also been confirmed in these species in Kentucky. This has further emphasized a need for diverse herbicide programs to not only control existing resistant weeds, but also in mitigating future resistance. Producers previously relied heavily on soil residual herbicides followed by a limited number of postemergence options to control these weeds. The number of postemergence options has expanded in the last two years with the introduction of dicamba-tolerant soybean and will be further expanded in the near future with a new generation of soybean with combined tolerance to glyphosate, dicamba, and glufosinate. Field studies evaluating pre-emergence and postemergence herbicide combinations in a glyphosate-, dicamba-, and glufosinate-soybean variety were conducted in 2018 at three Kentucky locations with infestations of glyphosate-resistant *A. tuberculatus* or *A. palmeri*. A factorial arrangement was used to evaluate three pre-emergence herbicides followed by five postemergence herbicide combinations in a randomized complete block design with four replications at each site. Pre-emergence herbicides included pyroxasulfone, pyroxasulfone plus flumioxazin, and S-metolachlor plus metribuzin plus fomesafen. Postemergence combinations included: dicamba, glufosinate, dicamba followed by glufosinate, dicamba plus acetochlor, and glufosinate plus acetochlor. Visual evaluations 21 days after pre-emergence application showed greater control with the pre-emergence applications with three site of action than the single site of action pre-emergence application. Treatment combinations reduced Amaranthus densities by 97 to 100% as compared to the untreated check at all three locations with no differences between treatments. Analysis of pre-emergence and postemergence treatment factors revealed that Amaranthus densities at the end of the season were influenced by pre-emergence applications with the multiple site of action treatments having greater density reduction than the single site of action product. Postemergence applications following pre-emergence treatments did not have an influence on Amaranthus densities. Results from these studies highlight the flexibility of the multiple effective postemergence options in this new generation of soybeans while emphasizing the importance of the continued use of multiple site of action pre-emergence products to control these two Amaranthus species.

DICAMBA VOLATILITY FROM PLANTS VS. SOILS. Donald Penner*[1], Jan Michael[2]; [1]Michigan State University, E Lansing, MI, [2]Michigan State University, East Lansing, MI (157)

Past research has shown that in hard water, the activity of growth regulator herbicides increases with application of water conditioners. This would facilitate application of lower herbicide rates. Volatility has been shown to be a function of the amount applied. Since volatility is also a function of temperature, early spring application of these herbicides to winter wheat had less vapor drift problems. Furthermore, sensitive crops in the vicinity were not present. This study focused on dicamba formulations developed for application to soybean. Injury to tomatoes, the bioassay species for this study, was evaluated 7 to 21 days after treatment. The applications were made 2, 4 and 6 days prior to the exposure of the tomatoes. The application of dicamba formulations were made separately and simultaneously to pots of soybean and to pots of bare soil. Volatility was greater from soybean than from bare soil. Generally there were few or only small statistical differences among dicamba formulations including the diglycolamine formulation.

EFFICACY OF HPPD-INHIBITING HERBICIDES APPLIED PREEMERGENCE OR POSTEMERGENCE FOR CONTROL OF MULTIPLE RESISTANT WATERHEMP (*AMARANTHUS TUBERCULATUS* VAR. *RUDIS*). Lauren Benoit*[1], Peter Sikkema[2], Darren Robinson[2], Dave Hooker[2]; [1]University of Guelph, Kirkton, ON, [2]University of Guelph, Ridgetown, ON (158)

Waterhemp (*Amaranthus tuberculatus*) is a competitive, highly-prolific, summer annual, broadleaf weed. Waterhemp populations resistant to up to three herbicide modes-of-action, Groups 2, 5 and 9, have been recorded at 48 locations in Ontario from a survey conducted in 2014 and 2015. A survey was conducted in 2016 and 2017 to identify additional sites with herbicide-resistant waterhemp in Eastern Canada. Waterhemp seed was collected from 23 new location through random and directed field scouting, 22 in Ontario and 1 in Quebec. Waterhemp was screened in the greenhouse for resistance to: imazethapyr (75 g ai ha^{-1}), atrazine (1000 g ai ha^{-1}), glyphosate (900 g ae ha^{-1}), and lactofen (110 g ai ha^{-1}), representing Group 2, 5, 9 and 14 herbicides, respectively. Of the 23 samples collected in 2016-17: 100% of the sites had biotypes that were resistant to imazethapyr, 88% to atrazine, 84% to glyphosate and 43% to lactofen. Forty-three percent of the populations had individual plants with resistance to all four herbicides. This is the first report of a Group 14 weed in eastern Canada. Field studies were conducted in 2017 and 2018 to determine the relative efficacy of Group 27 herbicides plus atrazine, applied PRE or POST, for the control of multiple-resistant waterhemp in corn. At four wk after application (WAA), isoxaflutole + atrazine and mesotrione + atrazine, applied pre-emergence, controlled waterhemp 93 and 91%, respectively. At four WAA, topramezone + atrazine and mesotrione + atrazine, applied postemergence, controlled waterhemp 87 and 93%, respectively.

MANAGEMENT OF GLYPHOSATE- AND HPPD INHIBITOR-RESISTANT PALMER AMARANTH IN CORN.

Vipan Kumar*[1], Rui Liu[1], Ednaldo A. Borgato[1], Phillip Stahlman[1], Pete Forster[2] [1]Kansas State University, Hays, KS, [2]Syngenta Crop Protection (159)

Palmer amaranth (*Amaranthus palmeri* S. Watson) is one of the most problematic broadleaf weeds in agronomic crops in the US, including Kansas. The rapid evolution of multiple-herbicide resistance in Palmer amaranth is an increasing management challenge for growers. The main objective of this research was to determine the effectiveness of soil residual pre-emergence (PRE), and PRE followed by (fb) tank-mixtures of soil-residual and foliar active postemergence (POST) herbicide programs for controlling multiple-resistant Palmer amaranth in corn. A study was conducted in a grower's corn field during 2018 growing season near Seward in Stafford County, Kansas. The Palmer amaranth population in this field has shown multiple resistance to glyphosate (Group 9) and mesotrione (Group 27). Total eleven herbicide programs (two PRE only and nine PRE fb POST) were evaluated. PRE treatments were applied with glyphosate at 1060 g ae ha^{-1}. Treatments were arranged in a randomized complete block design with four replications. The contrast analyses indicated that PRE applied dicamba (280 g ha^{-1}) plus bicyclopyrone/mesotrione/S-metolachlor/atrazine (1926 g ha^{-1}) plus saflufenacil (997 g ha^{-1}) provided 97% Palmer amaranth control at three wk after PRE (WAPRE), which did not differ for dicamba (280 g ha^{-1}) plus bicyclopyrone/mesotrione/S-metolachlor/atrazine (1445 to 2890 g ha^{-1}) alone or in combination with other tank-mixtures, such as atrazine (280 g ha^{-1}), mesotrione (35 g ha^{-1}), S-metolachlor (535 g ha^{-1}), isoxaflutole (129 g ha^{-1}), or metribuzin (157 g ha^{-1}) applied PRE. Palmer amaranth control with PRE only programs (dicamba plus bicyclopyrone/mesotrione/S-metolachlor/atrazine and dicamba plus isoxaflutole plus atrazine) declined over the season and was only 63 to 75% at final rating. Among tested programs, dicamba (280 g ha^{-1}) plus bicyclopyrone/mesotrione/S-metolachlor/atrazine (1926 g ha^{-1}) plus saflufenacil (997 g ha^{-1}) fb bicyclopyrone/mesotrione/S-metolachlor/atrazine (963 g ha^{-1}) plus glyphosate (1060 g ha^{-1}) provided complete, season-long Palmer amaranth control. Other PRE fb POST herbicide programs had 80 to 87% control at six weeks after POST (WAPOST). These results suggest that PRE fb POST programs that include tank-mixtures of herbicides with soil residual and foliar activity can provide effective control of Palmer amaranth with multiple resistance to glyphosate and HPPD inhibitors in corn.

CHARACTERIZATION OF TWO MULTIPLE HERBICIDE-RESISTANT WATERHEMP POPULATIONS FROM ILLINOIS TO GROUP 15 HERBICIDES. Seth Strom*, Lisa Gonzini, Charlie Mitsdarfer, Adam S. Davis, Dean E. Riechers, Aaron Hager; University of Illinois, Urbana, IL (160)

Group 15 herbicides, although discovered in the 1950s, remain an important resource for pre-emergence (PRE) control of annual grasses and small-seeded broadleaves. Previous and ongoing research with a five-way resistant population of waterhemp (*Amaranthus tuberculatus*) from Champaign County, IL (designated CHR) demonstrates that Group 15 herbicides alone are not effective for PRE control of the population. Acetochlor, alachlor, and pyroxasulfone provide the greatest PRE control of CHR under field conditions, while S-metolachlor and dimethenamid-P provided less control. A similar observation had been previously reported for another multiple herbicide-resistant (MHR) waterhemp population from Mclean County, IL (designated MCR). Since both CHR and MCR are resistant to S-triazine, HPPD-, and ALS-inhibiting herbicides, the objectives of this research were to compare CHR and MCR to other waterhemp populations in a controlled growth environment and investigate a possible association among the various known resistances and Group 15 efficacy. Progeny generated from each MHR population (CHR-M6 and MCR-NH40) were compared to another MHR waterhemp population from Illinois (ACR; S-triazine, ALS- and PPO-inhibitor resistant) and a known herbicide-sensitive population (WUS) under greenhouse conditions for their responses to four Group 15 active ingredients. Based on biomass reduction (GR_{50}) values, calculated resistant-to-sensitive ratios (R/S) between CHR-M6 and WUS were 7.5, 6.1, 5.5, and 2.9 for S-metolachlor, acetochlor, dimethenamid-P, and pyroxasulfone, respectively. R/S ratios between CHR-M6 and WUS where larger when calculated using seedling survival (LD_{50}) and values were greater for MCR-NH40 than CHR-M6. ACR was the most sensitive to all Group 15 herbicides tested. Results from these greenhouse studies complement and corroborate previous findings from the field. Future research is planned to further investigate the CHR and MCR populations and determine whether an edaphic factor or a physiological factor, such as rapid metabolism, is responsible for the differences in activity among the Group 15 active ingredients tested under both environments.

PREDICTING THE RELATIVE LONG-TERM EFFECTIVENESS OF HERBICIDE PROGRAMS USING SYNGENTA & RSQUO;S RESISTANCE FIGHTER MODEL. R. Joseph Wuerffel*[1], Cheryl L. Dunne[1], Ethan T. Parker[1], Eric Palmer[2], Dane L. Bowers[2], Deepak Kaundun[3], Chun Liu[3]; [1]Syngenta Crop Protection, Vero Beach, FL, [2]Syngenta Crop Protection, Greensboro, NC, [3]Syngenta Crop Protection, Braknell, England (161)

Successful stewardship of weed management tools (herbicides, tillage, cover crops, etc.) requires a focus on weed seed bank management; however, there are numerous logistical and experimental challenges when attempting to address these long-term research questions using traditional field trials. Even more challenging is convincing growers to adopt practices that do not necessarily afford short-term gain, but may reduce soil seed bank densities subsequently providing a potential return on investment after multiple years. Modeling weed management practices can be useful to meet these objectives given that modeling is not limited to time constraints and uncontrollable environmental factors. A generalized individual-based model was developed by Liu et al. (2017) that uses a novel approach for herbicide resistance modeling. In this model, biological parameters influence individual weeds and weed seeds as opposed to influencing the population as a whole. Furthermore, biological parameters such as seed production, emergence time, and quantitative resistance are represented by a range of responses which allows every individual in the model to have a stochastic and unique response, thereby accounting for natural variation. This model has been adapted specifically for *Amaranthus tuberculatus* in corn and soybeans and a user interface was developed to allow for direct interaction with standard computing capabilities.

CONTROL OF MULTIPLE HERBICIDE-RESISTANT HORSEWEED (*CONYZA CANADENSIS* L. *CRONQ*.) AND WATERHEMP (*AMARANTHUS TUBERCULATUS* VAR. *RUDIS*) WITH TOLPYRALATE.. Brendan A. Metzger*[1], Nader Soltani[2], Alan J. Raeder[3], Dave Hooker[2], Darren Robinson[2], Peter Sikkema[2]; [1]University of Guelph - Ridgetown, Ridgetown, ON, [2]University of Guelph, Ridgetown, ON, [3]ISK Biosciences, Concord, OH (162)

Tolpyralate, a recently commercialized herbicide, inhibits the 4-hydroxyphenylpyruvate dioxygenase (HPPD) enzyme in susceptible plants. Applied postemergence (POST), alone or in tank-mixtures with atrazine, tolpyralate provides control of several annual grass and broadleaf weed species in corn. Multiple-resistant (MR) Canada fleabane (Groups 2 and 9), and MR waterhemp (Groups 2, 5, 9 and 14), are an evolving weed management challenge in Ontario. Field studies to examine tolpyralate dose response in these species, and compare to commercial standard herbicides were conducted in Ontario in 2017/2018 at four locations with populations of MR Canada fleabane, and at three locations with populations of MR waterhemp. Treatments included six rates of tolpyralate from 3.75-120 g ai ha^{-1} applied alone or with atrazine in a 1:33.3 tank-mixture ratio. Commercial standards included dicamba/atrazine (1500 g ai ha^{-1}) and bromoxynil + atrazine (280 + 1500 g ai ha^{-1}) for control of MR Canada fleabane, and dicamba/atrazine (1500 g ai ha^{-1}) and mesotrione + atrazine (100 + 280 g ai ha^{-1}) for control of MR waterhemp. At eight WAA, tolpyralate + atrazine at 22.3 + 742 g ai ha^{-1}, applied POST, controlled MR Canada fleabane ≥95%, similar to both industry standards; however, no dose of tolpyralate alone provided >95% control. At 8 WAA, tolpyralate + atrazine at 57 + 1901 g ai ha^{-1}, applied POST, controlled MR waterhemp ≥95%, similar to both industry standards, while tolpyralate alone did not provide 95% control. These studies conclude that tolpyralate + atrazine provides excellent control of MR Canada fleabane and MR waterhemp, and is an effective herbicide option for in-season management of these species in corn.

PERMEATE: A NEW NPE-FREE NON IONIC SURFACTANT WITH UV PROTECTION. Thomas A. Hayden*[1], Gregory K. Dahl[2], Ryan J. Edwards[3], Jo A. Gillilan[4], Lillian c. Magidow[2], Joe V. Gednalske[2], Annie D. Makepeace[5]; [1]Winfield United, Owensboro, KY, [2]Winfield United, River Falls, WI, [3]Winfield Solutions, River Falls, WI, [4]Winfield United, Springfield, TN, [5]Winfield United, Shoreview, MN (163)

Introducing Permeate (NPE free surfactant-based adjuvant) from Winfield United. Permeate is a next generation non-ionic surfactant that will help optimize application coverage. Permeate has been shown to maximize pesticide performance by improving droplet spreading through decreased contact angles with minimal expected crop injury. Permeate also provides patented UV protection, which protects herbicides, insecticides and fungicides from photo degradation. Permenate can be applied whenever a pesticide label allows for the addition of a non-ionic surfactant.

RESPONSE OF WHITE AND YELLOW POPCORN HYBRIDS TO GLYPHOSATE, 2,4-D/GLYPHOSATE, OR DICAMBA. Ethann R. Barnes*[1], Stevan Knezevic[2], Nevin C. Lawrence[3], Oscar Rodriguez[4], Suat Irmak[1], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Wayne, NE, [3]University of Nebraska, Scottsbluff, NE, [4]Conagra Brands, Inc, Brookston, IN (164)

Drift, tank contamination, or misapplication risk of glyphosate, 2,4-D/glyphosate, and dicamba to popcorn production are important challenges and have not been assessed. A field experiment was conducted at the University of Nebraska—Lincoln, South Central Agricultural Laboratory, near Clay Center, NE, in 2017 and 2018 to determine the effects of glyphosate, 2,4-D/glyphosate, or dicamba on the injury, above ground biomass, and yield of white and yellow popcorn hybrids. Treatments included a weed-free control, non-treated control, and four rates of glyphosate (0.25X, 0.125X, 0.063X, and 0.031X), 2,4-D/glyphosate (0.25X, 0.125X, 0.063X, and 0.031X), and dicamba (2X, 1X, 0.5X, and 0.25X) applied POST at V5 or V8 popcorn growth stages. Visual estimates of herbicide injury, plant above ground biomass, and grain yield were quantified. Three-parameter log-logistic models were fit to each herbicide and model parameters and ED_5 values were compared between hybrids and application timings. Models were combined when parameters did not vary across hybrids (white or yellow) or herbicide application timings (V5 or V8). The ED_5 values for glyphosate injury at V5 and V8 were 3.4 and 57.6 g ae ha^{-1}, respectively, regardless of hybrid. The ED_5 values for plant biomass reduction when glyphosate was applied at V5 and V8 were 12.3 and 37.3 g ae ha^{-1}, respectively, regardless of hybrid. The ED_5 values for yield loss from glyphosate applied at V5 and V8 were 1.4 and 16.9 g ae ha^{-1}, respectively, regardless of hybrid. However, at other model parameters, the white popcorn hybrid resulted in greater injury, biomass reduction, and yield loss as compared with the yellow hybrid when glyphosate was applied. In white popcorn, the ED_5 values for 2,4-D/glyphosate injury at V5 and V8 was 6.0 and 19.2 g ae ha^{-1}, respectively; whereas, yellow popcorn at the V5 and V8 stages resulted in ED_5 values of 23.4 and 30.5 g ae ha^{-1}, respectively. The ED_5 values for plant biomass reduction in response to 2,4-D/glyphosate in white popcorn at V5 and V8 were 12.3 and 37.3 g ae ha^{-1}, respectively. The ED_5 value for plant biomass reduction in yellow popcorn was 38.3 g ae ha^{-1}, regardless of the crop growth stage when 2,4-D/glyphosate was applied. The ED_5 value for yield loss was 20.3 g ae ha^{-1}, regardless of stage or hybrid when 2,4-D/glyphosate was applied. Dicamba injury was best represented by a linear model based on AIC criteria. Regardless of application timing, dicamba resulted in 5% injury at 408.1 and 668.8 g ae ha^{-1} for white and yellow popcorn, respectively. Dicamba did not result in greater than 5% yield losses or biomass reduction, but resulted in substantial brace root malformation in both hybrids. Results from this experiment suggest that white popcorn is more susceptible to glyphosate or 2,4-D/glyphosate injury, biomass reduction, and yield loss and dicamba injury. Additionally, both herbicides at the V5 growth stage resulted in greater injury, greater biomass reduction, and greater yield loss than the V8 application.

TANKMIXTURE OF GGLYPHOSATE WITH 2,4-D ACCENTUATES 2,4-D INJURY IN GLYPHOSATE-RESISTANT CORN. Peter Sikkema*, Christy Shropshire, Nader Soltani; University of Guelph, Ridgetown, ON (165)

Six field trials were conducted at Ridgetown, Ontario over a two-year period (2015 and 2016) to determine the tolerance of two corn hybrids to 2,4-D (560 and 1120 g ai ha^{-1}) and glyphosate (1800 g ae ha^{-1}) applied alone or in combination at V1, V3 or V5. In DeKalb DKC52-61 corn, 2,4-D caused as much as 24, 16, 11 and 11% visible injury at 1 WAT, 2 WAT, 4 WA-C and 8 WA-C, respectively. Plant stand was not affected, but plant height decreased 5 cm at 560 g ai ha^{-1} and 7% at 1120 g ai ha^{-1}. As the application timing was delayed from V1 to V5, there was a trend to increase injury at both 2,4-D rates. Corn yield decreased 8% with 2,4-D applied at 560 g ai ha-^{1} and 12% at 1120 g ai ha^{-1}. In Pioneer P0094AM corn, 2,4-D caused as much as 16, 9, 7 and 7% visible injury at 1 WAT, 2 WAT, 4 WA-C and 89 WA-C, respectively. Plant height was not affected, but goose-necking and brace root malformation were increased as the rate of 2,4-D was increased. There was generally no difference between glyphosate rates (1800 vs 0 g ae ha^{-1}) at V1 corn stage but visible injury, goose-necking and brace root malformation at other application timings was as much as 15, 3 and 19% greater when 2,4-D was applied in a tank-mixture with glyphosate, respectively. Yield was reduced 12% when 2,4-D (1120 g ai ha^{-1}) was applied with glyphosate in the tank-mixture.

CONTROL OF GLUFOSINATE/GLYPHOSATE-RESISTANT VOLUNTEER CORN IN ENLIST™ CORN. Adam Striegel*[1], Nevin C. Lawrence[2], Stevan Knezevic[3], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska, Scottsbluff, NE, [3]University of Nebraska, Wayne, NE (166)

Nebraska is one of the largest corn producing states in the US with 42.8 million metric tons of corn produced in 2017 on about 2.14 million irrigated and 1.63 million non-irrigated hectares. While corn-soybean crop rotations are widely adopted, corn-on-corn production systems on highly productive irrigated fields are also common. This creates management issues with volunteer corn in corn fields. Enlist™ corn contains a new trait resistant to 2,4-D choline, glyphosate, and the aryloxyphenoxypropionates (FOPs), an acetyl CoA carboxylase (ACCase) inhibitor. The objectives of this study were to evaluate six ACCase-inhibiting herbicides applied to volunteer corn at two application heights (30 and 50 cm), corresponding with the sixth-leaf collar (V6) and eighth-leaf collar (V8) growth stages respectively for control of glyphosate/glufosinate-resistant volunteer corn, as well as determine crop injury and yield effects to Enlist™ corn. Field experiments were conducted in 2018 under irrigated conditions at the University of Nebraska–Lincoln South Central Agricultural Laboratory in Clay County, Nebraska. Glyphosate/glufosinate-resistant volunteer corn was cross-planted into the research plots at a density of 37,000 plants ha^{-1} one wk prior to planting the Enlist™ corn. Fluazifop, quizalofop, and fluazifop/fenoxaprop applied at both application timings provided 99% control of volunteer corn with excellent crop safety, with no reduction to crop yield. However, clethodim, sethoxydim and pinoxaden applied to volunteer corn at 50-cm height resulted in higher crop injury (98%, 97%, and 56%) at 28 DAT and lower crop yield (177 kg ha^{-1}, 465 kg ha^{-1}, and 4,291 kg ha^{-1}) in comparison to 30 cm applications with lower (61%, 76%, and 27%) crop injury at 28 DAT and higher crop yield (1,621 kg ha^{-1}, 1,954 kg ha^{-1}, and 9,787 kg ha^{-1}). In addition, 30 cm application timings resulted in higher volunteer corn biomass reduction compared to the 50 cm application timing at 21 DAT. Overall, the time of application of fluazifop, quizalofop, and fluazifop/fenoxaprop had no effect on volunteer corn control, corn yield or crop injury, while the crop injury and yield response of Enlist™ corn to clethodim, sethoxydim and pinoxaden applications was dependent on the application timing. Quizalofop (Assure II) is the only labeled product and can be recommended for effective control of volunteer corn in Enlist™ corn.

DEVELOPMENT OF ROBUST FOPS AND SYNTHETIC AUXIN HERBICIDE TOLERANCE TRAITS FOR GM CROPS. Clayton Larue*, Michael Goley, Oscar C. Sparks, Christine Ellis, Marguerite J. Varagona; Bayer Crop Science, Chesterfield, MO (167)

Effective management of weedy species in agricultural fields is essential for maintaining favorable growing conditions and crop yields. The introduction of genetically modified crops containing herbicide tolerance traits has been a successful additional tool available to farmers to better control weeds. However, weed resistance challenges present a need for additional options. To help meet this challenge, a new trait that provides tolerance to the aryloxyphenoxypropionate (FOPs) herbicides and members of the synthetic auxin herbicide family, such as 2,4-D, was developed. Development of this herbicide tolerance trait employed an enzyme engineered with robust and specific enzymatic activity for these two herbicide families. This engineering effort utilized a microbial-sourced dioxygenase scaffold to generate variants with improved enzymatic parameters. Additional optimization to enhance in-plant stability of the enzyme enabled an efficacious trait that can withstand the temperature conditions often found in field environments. The enhanced enzymatic and temperature stability parameters of the enzyme variants confer on transgenic corn (*Zea mays*) robust herbicide tolerance that is useful in weed management systems using these two herbicide families. This presentation will cover the development and testing of the FOPs and 2,4-D tolerance trait in the next generation corn herbicide tolerance package.

CRITICAL TIME OF WEED REMOVAL IN CORN AS INFLUENCED BY PRE-HERBICIDES. Ayse Nur Ulusoy*[1], O. Adewale Osipitan[2], Jon E Scott[3], Stevan Knezevic[4]; [1]University of Nebraska-Lincoln, Concord, NE, [2]University of Nebraska-Lincoln, Linconln, NE, [3]University of Nebraska, Wakefield, NE, [4]University of Nebraska, Wayne, NE (168)

The use of pre-emergence (PRE) herbicides for weed control could reduce the need for multiple postemergence (POST) applications of glyphosate in glyphosate-tolerant (GT) corn and provide additional mode of action for combating glyphosate-resistant weeds. Thus, field studies were conducted in 2017 and 2018 near Concord, NE, to evaluate the influence of PRE herbicides on critical time of weed removal (CTWR) in GT corn. The studies were arranged in a split-plot design with three herbicide regimes as main-plot treatments and seven weed removal timings as sub-plot treatments in four replications. The herbicide regimes included No-PRE and two PRE herbicide treatments which were atrazine and Verdict®-Zidua® (saflufenacil plus dimethenamid plus and pyroxasulfone) in 2017 and 2018. The weed removal timings were at V3, V6, V9, V12, and V15 corn growth stages, as well as weed free and weedy season-long treatments. The relationship between relative corn yields and weed removal timings was described by a four parameter log-logistic model and the CTWR was estimated based on 5% yield loss. Delaying weed removal time reduced corn yield, particularly without PRE application of herbicides. In 2017, the CTWR started at V3 without PRE herbicide while PRE application of atrazine and Verdict®-Zidua® delayed the CTWR to V5 and V10, respectively. In 2018, the CTWR started at V5 without PRE herbicide, and application of atrazine did not delay the CTWR. The general delay in CTWR in 2018 could be attributed to low weed pressure and relatively high rainfall that prevents corn growth and yield reduction. The studies confirmed that PRE application of herbicides could delay the need for POST application of glyphosate for weed control in GT corn.

INTERACTIONS BETWEEN RESIDUAL HERBICIDES AND TERMINATION TIMING IN CEREAL RYE ON SUMMER ANNUAL WEEDS IN INDIANA CORN SYSTEMS. Wyatt S. Petersen*, William G. Johnson; Purdue University, West Lafayette, IN (169)

The spread of herbicide-resistant weeds has led many growers to explore alternative forms of weed management. Cover crops and residual herbicide pre-mixtures have been advocated by many as effective tools for weed control in conventional agriculture. Cereal rye (*Secale cereale*) is often used for weed suppression. Understanding how cereal rye and residual herbicides interact is important for conventional growers wanting to incorporate cover crops into crop rotations. One main concern with residual herbicides in cereal rye and other cover crops is that herbicide will stay in the residue and not contact soil. Field studies were performed at three different locations in Indiana. Fall planted cereal rye (103 kg ha^{-1}) was terminated either two wk before corn planting or at corn planting, using glyphosate alone or in tank-mixtures with atrazine, S-metolachlor, mesotrione, and bicyclopyrone. The same treatments were applied to plots containing no cereal rye cover as a burndown application. A POST application was also made 3-4 weeks after corn planting on plots with glyphosate, dicamba, and diflufenzopyr together or also with tank-mixtures with atrazine and S-metolachlor. Total weed biomass was collected before the POST application and in late September. Dominant weed species at the locations included giant ragweed (*Ambrosia trifida*), giant foxtail (*Setaria faberi*), cocklebur (*Xanthium strumarium*), horseweed (*Erigeron canadensis*), and waterhemp (*Amaranthus tuberculatus var. rudis*). In glyphosate-only termination/burndown made two wk before planting, weed biomass was reduced for weeds at the POST application, and average weed biomass was reduced by 46-86% at all locations. In treatments receiving residual herbicide at termination/burndown, there were no differences in biomass or percent control at any site. Late season biomass was insignificant for all weed species with the exception of cocklebur. Late-season cocklebur biomass was higher in cereal rye plots than in plots containing no cover crop. This is likely due to the lack of herbicide-soil contact due to herbicide interception, as well as the late-emerging, large cocklebur seed able to push through the rye residue. As weed density, biomass, and average weed biomass were smaller for weeds at the POST application, these results suggest that cereal rye could extend the window for effective POST applications, and possibly reduce the number of herbicide applications required for adequate weed control.

EFFECTS OF COVER CROP PLANTING AND TERMINATION TIME ON WEED DEMOGRAPHICS AND CORN PRODUCTIVITY IN SEMI-ARID RAINFED CROPPING SYSTEMS OF WESTERN NEBRASKA. Alexandre Tonon Rosa*[1], Italo Kaye Pinho de Faria[2], Liberty E. Butts[3], Cody F. Creech[4], Roger Elmore[1], Daran Rudnick[2], Rodrigo Werle[5]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska Lincoln, North Platte, NE, [4]University of Nebraska-Lincoln, Scottsbluff, NE, [5]University of Wisconsin-Madison, Madison, WI (170)

Producers are questioning whether the incorporation of cover crops (CC) in semi-arid areas would aid weed management and impact grain yield of subsequent crops. The objective of this study was to evaluate the impact of CC selection, planting and termination time on CC biomass production, weed demographics, and subsequent corn productivity. Treatments consisted of three planting times (three, six, and nine wk after winter wheat harvest) and four CC termination times: i) winter-sensitive mixture killed in the winter, ii) winter-hardy mixture terminated with glyphosate three wk before corn planting, iii) winter-hardy mixture terminated with glyphosate at corn planting, and iv) no CC. The study was established in 2017 and 2018 at North Platte and Grant, western NE. CC biomass was collected in the fall and spring. Corn was planted mid- to late-May. Weed density and biomass were recorded when corn reached the V6 growth stage. The experiment was conducted in a randomized complete block design with four replications. Results indicate that CC planting time has an impact on total biomass accumulation in the fall and spring. Earlier planting time produced higher CC biomass in the fall in both years and locations; spring biomass accumulation was site-year dependent. Weed density and biomass were reduced by CC treatments with substantial growth in the spring. Between sites, spring CC growth reduced weed biomass up to 537%. Overall, CC reduced corn yield by 5% or more in North Platte and 13% or more in Grant. The winter-hardy late planting and early termination treatment combination had the least impact on corn yield (8687 and 7382 kg ha^{-1} in North Platte and Grant, respectively). Properly managed CC have the potential to suppress weeds. However, in rainfed areas, early CC termination is key to avoid excessive CC growth and yield penalties of subsequent crop(s).

WEED CONTROL IN CORN WITH INCREASING LEVELS OF IRRIGATION WITH AND WITHOUT A WHEAT COVER CROP. Randall S Currie*, Patrick Geier; Kansas State University, Garden City, KS (171)

A killed winter wheat (*Triticum aestivum* L.) cover crop (CC) under limited irrigation has increased corn yield despite the opportunity cost of the water used to grow it (Weed Science, 2005, 53: 709-716). Furthermore, this research showed that a CC can improve weed control. In that study, only two levels of irrigation were possible. Therefore, the main objective of this research was to measure yield and weed control under a broad range of irrigations with and without a killed winter wheat CC. The experimental design was a randomized complete block with four replications in a split-plot arrangement. The main plot factor was irrigation level and CC was sub-plot factor. Six irrigation levels (100, 75, 50, 25, 15, and 0% of full evaporative demand) within each replication were used. Each irrigation level was split into a winter wheat CC portion planted in the fall prior to spring planting and a no CC portion. A wk before corn planting in the spring of 2014, a tank mixture consisting of glyphosate + S-metolachlor + mesotrione + atrazine at 1.4 + 2 + 0.2 + 0.78 kg ha^{-1} was applied over the entire plot area to kill the winter wheat CC and to provide the pre-emergence herbicides for subsequent corn crop. This experiment was repeated in 2015, 2017 and 2018. A planter malfunction in 2017 rendered the after planting data useless. Prior to corn planting, the CC produced a 5- to 20-fold reduction in kochia (*Bassia scoparia* L.) in all years and produced 7- and 31-fold reduction in Russian thistle (*Salsola tragus* L.) in two years and 100% control in 2017 and 2018. Common lambsquarters (*Chenopodium album* L.) was only present in two years and was controlled at 20- and 169-fold prior to corn planting. Averaged over levels of irrigation, CC increased corn yields in all years between 8 and 48% with an average increase of 1857 kg ha^{-1}. The CC often elevated yield in 2014 and 2015, however, this elevation was only significant at the levels greater than 25% of evapotranspiration (ET) and most often at levels higher than 75% of ET. In 2014, yield was described by the equation kg ha^{-1} = 61.1 * % ET + 2184 with a CC (R^2 = 0.76) and kg ha^{-1} = 46.2 * % ET + 1258 in the absence of a CC (R^2 = 0.83). In 2015, although yields across irrigation levels were higher in the presence of CC with a slope of 0.34 for cover and 0.09 for no cover, response to irrigation was less pronounced (R^2 < 0.43). In 2018, although CC yields were higher than no-CC yields across irrigation rates, the slopes of these lines were nearly identical; 0.91 and 0.92 for cover and no-cover, respectively. A linear response to level of irrigation was seen in 2018 with R^2 of 0.91 and 0.83 for cover and no-cover, respectively. This suggests that yields might have been less variable in the presence of a CC. These results confirm previous work (Weed Science, 2005, 53: 709-716) and show that the benefits of a killed winter wheat CC to yield and weed control extend over a broad range of moisture conditions but are most pronounced at higher levels of irrigation.

ORGANIC HERBICIDES AS A WEED MANAGEMENT TOOL IN SOYBEANS. Betzy Valdez*, Kerry M. Clark, Reid Smeda; University of Missouri, Columbia, MO (172)

Approximately 80% of soybeans (*Glycine max*) supplying the US organic market are imported. Grower adoption of organic practices for soybean to meet this need is limited by the lack of effective weed management. The objective of this research was to determine if post-directed organic herbicides could effectively control weeds and preserve crop yield. In three m wide plots, soybean was planted in 76-cm rows in central Missouri in 2017 and 2018. As weeds reached eight cm in height, repeated application of plant oils (manuka, clove + cinnamon, or d-limonene) and acids (acetic or caprylic + capric) were made at 374 L ha^{-1} between crop rows using a shielded sprayer. A hand weeded and untreated control were also included. Herbicide injury varied with each application; manuka oil caused bleaching of sensitive plants, especially yellow nutsedge (*Cyperus esculentus*) and grasses; acidic herbicides resulted in contact necrosis. A total of five to six applications were made between crop emergence and canopy closure. At the end of the season in both 2017 and 2018, herbicides reduced weed biomass by 84 to 100% and 64 to 91%, respectively, compared to the untreated control. Caprylic + capric acid was the most effective treatment over both years, resulting in 28 and 62% injury in 2017 for broadleaves and grasses, respectively, and 100 and 75% in 2018. Over the two years, waterhemp (*Amaranthus tuberculatus*) was highly sensitive to caprylic + capric acid in comparison to other herbicides. In 2018, caprylic + capric acid and the weed-free control resulted in a 12 and 14% yield increase, respectively, compared to the untreated control. Despite effectiveness on weeds between crop rows, weeds growing in crop rows were relatively uninjured. Due to the high demand for organic soybeans in the US, organic herbicides may be a viable tool in an integrated weed management program.

PALMER AMARANTH AND WATERHEMP CONTROL WITH INTEGRATED STRATEGIES IN GLUFOSINATE-RESISTANT SOYBEAN. Marshall M. Hay*, Anita Dille, Dallas E Peterson; Kansas State University, Manhattan, KS (173)

Successful pigweed management requires an integrated strategy to delay the evolution of resistance to any single control tactic. Field trials were implemented during 2017 and 2018 in three counties in Kansas on dryland glufosinate-resistant soybean. The objective was to assess the control of pigweed with a winter wheat cover crop (CC), three row widths (76-, 38-, and 19-cm), row-crop cultivation (RC) at 2.5 wk after planting (WAP), and an herbicide program to develop integrated pigweed management recommendations. Sixteen treatments were developed to assess all possible combinations of the four components. Treatments containing the herbicide program component resulted in excellent (> 97%) pigweed control and were analyzed separately from the weedy cohort. Treatments containing RC tended to reduce pigweed density and biomass at three and eight WAP in all locations compared to the 76-cm row width no cover crop treatment. Mixed results were observed when the effect of CC was considered: at Riley County, reductions in pigweed density and biomass were observed, at Reno County CC contributed no additional control, and at Franklin County, CC increased pigweed density and biomass. Decreased row widths achieved the most consistent results by reducing pigweed biomass at eight WAP when data were pooled across location: decreasing row widths from 76-cm to 38-cm resulted in a 23% reduction whereas decreasing from 38-cm to 19-cm achieved a 15% reduction. In conclusion, RC should be incorporated where possible as a mechanical option to manage pigweed, and decreased row widths should be used when economically feasible to suppress late-season pigweed growth. CC achieved inconsistent pigweed control in this research and should be given special consideration prior to implementation. The integral use of these components with an herbicide program as a system should be recommended to achieve the best pigweed control as well as reduce the risk of resistance.

DICAMBA SIMULATED TANK-CONTAMINATION INJURY FROM POST-EMERGENCE HERBICIDE APPLICATIONS ON NON-DICAMBA-TOLERANT SOYBEAN. Milos Zaric*[1], Bruno Canella Vieira[2], Guilherme Sousa Alves[3], Jeffrey Golus[1], Greg R Kruger[3]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska, North Platte, NE (174)

Increased instances of glyphosate- and other herbicide-resistant weeds in the United States has led to development of additional management tools such as dicamba-tolerant crops. Although the adoption of dicamba-tolerant crops provided farmers a new valuable approach to control troublesome weeds, the technology has concerns regarding dicamba off-target movement causing undesirable effects on sensitive vegetation. Tank contamination, physical particle drift, and volatility are among several factors that may contribute to unintended dicamba symptomology on sensitive crops. Currently, there are few available studies investigating dicamba tank contamination in different tank-mixtures. A field experiment was conducted at the West Central Research and Extension Center in North Platte, Nebraska during summer 2018 to determine the impact of commonly applied postemergence herbicides with simulated dicamba tank contamination on non-dicamba-tolerant soybean (Glycine max (L.) Merr.). The experiment was conducted in a randomized complete block design with a factorial treatment arrangement with four replications. Each plot consisted of six rows of non-dicamba tolerant soybean (0.76 m apart and 7.6 m long). Treatments included untreated check, two glyphosate formulations, five ACCase-inhibiting herbicides, and three PPO-inhibiting herbicides combined with three sub-labeled rates of dicamba as tank contaminants (0, 0.1, and 0.01% of the 560 g ae ha-1 label rate). Herbicide treatments were applied on two soybean fields at different growth stages (V3 and R2, respectively) using a CO2 backpack sprayer with a six-nozzle boom calibrated to deliver 140 L ha-1 using AIXR110015 nozzles at 345 kPa. Soybean yield, visual estimations of injury and plant height (7, 14, 21, and 28 DAT) were recorded. Soybean yield was influenced by the interaction of herbicide tank-mixture and dicamba rate for both vegetative ($p=0.0207$) and reproductive ($p=0.0154$) application timings. Soybean height was influenced by herbicide tank-mixture on both vegetative ($p=0.0009$) and reproductive ($p=0.0010$) applications timings, whereas dicamba rate influenced soybean height just in the vegetative application timing ($p<0.0001$). In general, PPO-inhibiting herbicides caused more soybean injury and yield loss. Even though PPO-inhibiting herbicides in combination with dicamba caused greater injury the effect on yield was dependent on PPO-inhibiting herbicide and dicamba rate.

EFFECT OF ROW SPACING AND HERBICIDE PROGRAMS ON GLYPHOSATE-RESISTANT PALMER AMARANTH CONTROL IN DICAMBA-RESISTANT SOYBEAN IN NEBRASKA. Parminder Chahal*[1], Carl W. Coburn[2], Amit Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Bayer Crop Science, Gothenburg, NE (175)

A Palmer amaranth biotype resistant to glyphosate was reported on a grower’s farm under continuous corn-soybean rotation near Carleton, Nebraska. A field study was conducted at that site to evaluate effect of row spacing and pre-emergence (PRE) followed by postemergence (POST) herbicide programs on control of glyphosate-resistant Palmer amaranth in dicamba/glyphosate-resistant soybean. The experiment was arranged in a split-plot design with soybean row spacing (37.5- and 75-cm) as the main factor and 15 herbicide programs including non-treated control as split plot. A soybean seed population of 350,000 seeds ha^{-1} was planted for both row spacings. Soybean row spacing had no effect on Palmer amaranth control throughout the season except at 28 d after PRE (DAPRE) and 21 d after late-POST (DAL-POST), 15-cm row spacing showed greater (77 to 86%) control compared to 30-cm (73 to 80%). Most PRE herbicides provided 93 to 96% control except dicamba applied PRE provided 83% control at 28 DAPRE. At 14 d after early-POST (DAE-POST), PRE herbicides followed by dicamba POST provided 78 to 96% control compared to 62 to 68% control with dicamba POST alone. Similarly, row spacing had no effect on Palmer amaranth density at 14 DAE-POST. Late-POST application of dicamba was made at 21 DAE-POST. Most PRE followed by dicamba POST programs provided greater (94 to 99%) control compared to dicamba POST alone (82%); however, sequential POST application of dicamba provided similar (84%) control as single dicamba application at 21 DAL-POST. Soybean yield was not affected by row spacing or its interaction with herbicide programs; therefore, data were combined over row spacing. Most PRE herbicides followed by dicamba POST, dicamba POST alone, or dicamba POST sequential applications provided similar (618 to 1,097 kg ha^{-1}) soybean yield.

RESPONSE OF INSECT PEST AND BENEFICIAL SPECIES TO THE TIMING AND SEVERITY OF DICAMBA INJURY IN SOYBEAN. William A. Tubbs*, Kevin Rice, Mandy Bish, Kevin W Bradley; University of Missouri, Columbia, MO (176)

Off-target movement of dicamba has been one of the most significant issues to affect non-dicamba-tolerant (DT) soybean production during 2017 and 2018. Although a variety of research has been conducted to determine the effects of off-target dicamba movement on soybean yield, few studies have been conducted to understand the effects that dicamba injury has on insect infestations in non-DT soybean. A field experiment was conducted at four locations in Missouri to determine if dicamba injury to non-DT soybean has any effect on the prevalence and severity of insect pest and beneficial species throughout the growing season. At each location, herbicide treatments were applied to non-DT soybean at either the V3 or R1 stages of growth. The treatments evaluated included dicamba at rates corresponding to 1/10th, 1/100th, 1/1,000th, and 1/10,000th of the labeled use rate (560 g ae ha^{-1}) and lactofen at 175 g ae ha^{-1}. A non-treated control was also included for comparison. The experiment was conducted in a randomized complete block design. Individual plots were six m by six m and replicated six times. Insects were collected by sweep net sampling beginning the day of application and at seven day intervals following application up to 77 days after treatment. Upon collection, insects were frozen and stored for subsequent identification and analysis. Preliminary results from two of the four locations indicates that insect pest species abundance was lowest in non-DT soybean that received an application of dicamba at 1/10th the labeled rate at either the V3 or R1 application timing. However, insect pest species density was much higher in non-DT soybean that received an R1 application of lactofen or dicamba at rates lower than 1/10th the labeled rate. Results thus far indicate that dicamba injury to soybean does not result in a higher incidence of insect pests in soybean compared to the non-treated control.

TOLERANCE OF MIDWEST SOYBEAN CULTIVARS TO PREEMERGENT APPLICATIONS OF METRIBUZIN AND SULFENTRAZONE. Thomas R. Butts*[1], Maxwel Coura Oliveira[2], Nikola Arsenijevic[3], Shawn P. Conley[2], Rodrigo Werle[2]; [1]University of Arkansas, Lonoke, AR, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Nebraska Lincoln, North Platte, NE (177)

Herbicide-resistant weeds have resurged the need for soil residual pre-emergence (PRE) herbicides, such as metribuzin and sulfentrazone, in soybean production systems. These are recognized for potential early-season crop injury, especially in cool and wet conditions. The objectives of this research were to: i) evaluate the tolerance level of 221 soybean Midwest-adapted cultivars [maturity group (MG) range 0.3 to 2.9] to metribuzin and sulfentrazone, and ii) identify whether MG, seed treatment, brand, herbicide-tolerance trait, and early-season vigor influence cultivar tolerance to these herbicides. A greenhouse experiment was conducted at the University of Wisconsin-Madison as a completely randomized design with 221 soybean cultivars screened with three herbicide treatments (metribuzin, sulfentrazone and non-treated; three replications $treatment^{-1}$) and replicated twice. Experimental units consisted of square pots (10 cm wide by 9 cm deep) filled with Plano Silt Loam field soil (pH = 6.6, OM = 3.1%) containing three soybean seeds sown three cm deep. The day seeds were planted, metribuzin and sulfentrazone were applied at 0.56 and 0.28 kg ai ha^{-1}, respectively, using a single-nozzle track research sprayer. Visual estimations of tolerance were made when soybeans were transitioning from V1 to V2 growth stages. Random forest analysis determined approximately 33% of the variance in the dataset could be explained with the aforementioned explanatory variables. Early-season vigor was the most influential factor affecting herbicide tolerance of soybean with a negative Pearson correlation (-0.34; $P < 0.0001$). The negative correlation between early-season vigor (evaluated from the non-treated pots) and tolerance ratings may be attributed to either an inherent bias of visual injury assessments as healthier plants provide the opportunity of “greater injury” to occur, or low early-season vigor cultivars being more tolerant to injury from PRE herbicides due to uncharacterized physiological constraints. Tolerance ratings of metribuzin and sulfentrazone were positively correlated (0.26, $P = 0.0001$); however, variability in tolerances were noted. Soybean MG had a stronger correlation with sulfentrazone tolerance (-0.27, $P < 0.0001$) than metribuzin tolerance (0.05, $P = 0.4760$); as MG increased by one, sulfentrazone tolerance decreased by 0.05. Soybean cultivar brand, seed treatment, and herbicide trait minimally impacted cultivar tolerance to metribuzin and sulfentrazone herbicides. This research highlights the variation in tolerance of 221 Midwest-adapted soybean cultivars to metribuzin and sulfentrazone. Additionally, the importance of herbicide screenings such as this is evident as a cultivar selection aid for farmers and advisers searching for high yielding cultivars with reduced likelihood of early-season soybean injury from PRE applications of metribuzin and sulfentrazone herbicides.

INTEGRATING FALL-SEEDED CEREAL COVER CROPS FOR HORSEWEED MANAGEMENT IN NO-TILLAGE SOYBEAN. John A. Schramski*[1], Christy Sprague[2], Karen Renner[2]; [1]Michigan State University, East Lansing, MI, [2]Michigan State University, E Lansing, MI (178)

Herbicide-resistant horseweed continues to be a challenge for Michigan soybean growers. Multiple management strategies need to be considered to improve overall herbicide-resistant horseweed control. In 2018, an experiment was conducted in Mount Pleasant, Michigan to evaluate the effects of fall-planted cereal cover crops terminated at different timings to manage herbicide-resistant horseweed. The experiment was set up as a split-plot design with cover crop treatments of cereal rye and winter wheat drilled at two different seeding rates (67 and 135 kg ha^{-1}) in fall 2017 and a no cover control. Within each cover crop main-plot two herbicide treatment sub-plots were established that included cover crop termination treatments of glyphosate one wk prior to ("early termination") and one wk after soybean planting ("planting green"). Each herbicide treatment sub-plot received a POST application of dicamba. The majority of horseweed at this location emerged in the spring and peak horseweed emergence occurred in early-May; however, horseweed continued to emerge weekly through early-August. Planting green treatments had three times the cover crop biomass compared with the early termination treatments. Biomass averaged across the seeding rates of early terminated winter wheat and cereal rye was 864 and 1,546 kg ha^{-1}, respectively, whereas planting green biomass of winter wheat and cereal rye was 3,255 and 4,482 kg ha^{-1}, respectively. The high cover crop seeding rate increased cover biomass 28% compared with the low seeding rate at early termination, but cover crop seeding rate was not significant for the planting green treatments. Early terminated winter wheat and cereal rye reduced horseweed numbers compared with the no cover control by 60 and 49%, respectively. Planting green winter wheat and cereal rye treatments did not reduce horseweed numbers compared with the no cover control. However, biomass of other weeds (i.e., dandelion) was nine times greater in the no cover control than the cover crop treatments and may have influenced horseweed number and biomass. At the POST timing, residue from the cover crops did not decrease horseweed biomass or height compared with the no cover control. Following POST application of dicamba, cover crop treatments did not impact late summer-emerging horseweed rosettes compared with no cover control. Soybean yielded higher in the winter wheat and cereal rye cover crop treatments compared with the no cover control by 34 and 31%, respectively. Soybean yield was 25% higher in the planting green treatments averaged across cover crops compared with the early termination timing. Preliminary observations show that fall-planted cereal cover crops seeded at either rate and terminated one wk prior to and one wk after soybean planting may be utilized to aid in horseweed suppression. However, horseweed emergence time varies and fall-planted cereal cover crops alone will not provide season-long control of spring-emerging horseweed in no-till soybean.

WHAT NOT TO DO WHEN MULTIPLE HERBICIDE-RESISTANT SOYBEAN TECHNOLOGY COEXIST. Amit Jhala*; University of Nebraska-Lincoln, Lincoln, NE (179)

Multiple herbicide-resistant soybean such as dicamba/glyphosate-resistant soybean came to the market in 2017 growing season. Additionally, soybean resistant to isoxaflutole/glyphosate/glufosinate as well as 2,4-D cloline/glyphosate/glufosinate are set to be available in the near future. It is important to pay attention to the type of multiple herbicide-resistant soybean to understand which herbicide(s) it is resistant to. Misapplication of herbicides can result in complete crop failure. For example, if glyphosate-resistant soybean is sprayed by mistake with dicamba at a labeled rate, the crop would be killed. Similarly, if glufosinate is sprayed on dicamba/glyphosate-resistant soybean, the crop would be killed. A field experiment was conducted in Nebraska to highlight such a scenario to explain to stakeholders what to do and what not to do. Additionally, herbicide injury symptoms that developed were explained to differentiate between systemic and contact herbicides.

CONTROL OF ANNUAL WEEDS IN ISOXAFLUTOLE-RESISTANT SOYBEAN. Andrea Smith*[1], Allan C. Kaastra[2], David C. Hooker[1], Darren Robinson[1], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Bayer CropScience, Guelph, ON (180)

Transgenic crops are being developed with herbicide-resistance traits to provide innovative weed control options. Soybean conferring resistance to Group 27 herbicide isoxaflutole is currently under development and will provide a novel herbicide mode of action for use in soybean. Field experiments were conducted in 2017 and 2018 on five unique soil types using isoxaflutole-resistant soybean to evaluate annual weed control efficacy of pre-emergent (PRE) applied isoxaflutole and metribuzin at three different rate combinations including the low rate 52.5 and 210 g ai ha^{-1}, medium rate 79 and 315 g ai ha^{-1}, high rate 104 and 420 g ai ha^{-1} of isoxaflutole and metribuzin, respectively. These treatments were applied alone and with an application of glyphosate (900 g ai ha^{-1}) POST when weed escapes from the PRE applied herbicides were 7.5-cm tall. Control of common lambsquarters, and common ragweed differed between locations. Less control was seen at locations which received lower amounts of cumulative rainfall between the PRE and POST applications. Other species did not differ between locations. In general broadleaf weed control with the low rate ranged from 25 to 69%, control with the medium rate ranged between 49 and 86% and the high rate controlled broadleaf weeds between 71 and 95%. Grass weeds were controlled between 85 and 97% with the low rate, 75 and 99% with the medium rate and 86 to 100% with the high rate. Weeds were controlled 98 to 100% when a POST application of glyphosate was applied regardless of the rate of isoxaflutole and metribuzin applied PRE. To conclude, increasing rates of isoxaflutole and metribuzin provided better control of annual weeds and glyphosate applied post provided control of escaped weeds.

TAVIUM™ PLUS VAPORGRIP® TECHNOLOGY &NDASH; A TOOL FOR WEED MANAGEMENT IN CONVENTIONAL AND NO-TILL DICAMBA TOLERANT SOYBEAN. Aaron Franssen*[1], Brett Miller[2], Tom Beckett[3], Don Porter[3]; [1]Syngenta Crop Protection, Pleasant Dale, NE, [2]Syngenta Crop Protection, Fargo, ND, [3]Syngenta Crop Protection, Greensboro, NC (181)

Tavium® Plus VaporGrip® Technology is a new herbicide pre-mixture developed by Syngenta Crop Protection for use in dicamba-tolerant soybean and pending registration with the EPA. It will contain three key components: dicamba, a Group 4 herbicide, S-metolachlor, a Group 15 herbicide, and VaporGrip Technology which decreases the volatility of dicamba and reduces the chance for off-site movement. Upon registration, Tavium Plus VaporGrip Technology will provide postemergence control of over 50 broadleaf weeds as well as extended residual control of key broadleaf species such as waterhemp and Palmer amaranth as well as troublesome grasses. Tavium Plus VaporGrip Technology will offer flexibility in application timing by allowing one application from preplant burndown through pre-emergence and one application postemergence in dicamba-tolerant soybean. By employing two modes of action, Tavium Plus VaporGrip Technology will be an effective resistance management tool which will fit well into either conventional- or no-till systems by delivering postemergence control and enabling overlapping residual activity.

EFAME - A NEW CLASS OF EPA APPROVED SURFACTANTS FOR AGRICULTURAL USE. Kevin Crosby*[1], Tim Anderson[2]; [1]Adjuvants Unlimited, LLC, Memphis, TN, [2]BASF, Cincinnati, OH (182)

Ethoxylated fatty acid methyl esters (EFAMETM) are a new class of surfactants for use in agriculture. An exemption from tolerance was granted by the US EPA in June 2018, allowing for use of these materials as inert materials in pesticide formulations and adjuvants. Made from 40% sustainable raw materials, this class has several useful properties for use as non-ionic surfactants in herbicide formulations and adjuvants, including wetting comparable to alcohol ethoxylates, low propensity to form gel phases, low mammalian and aquatic toxicity, very low VOC and excellent biodegradability. Additionally, surprising solvent characteristics for some herbicide active ingredients have been discovered. Thus, EFAMETM can serve as the basis for environmentally safer herbicide formulations and adjuvants. Field trial results with different adjuvant formulations with several herbicides will be discussed.

GRAMOXONE MAGNUM: A NEW OPTION FOR BURNDOWN AND RESIDUAL WEED CONTROL. Ryan Lins*[1], Adrian J Moses[2], Monika Saini[3], Dane L. Bowers[3]; [1]Syngenta Crop Protection, Rochester, MN, [2]Syngenta Crop Protection, Gilbert, IA, [3]Syngenta Crop Protection, Greensboro, NC (183)

Gramoxone Magnum herbicide is a new product for burndown and residual control of grass and broadleaf weeds in corn, legume vegetables, sorghum, soybeans, and sunflower. Gramoxone Magnum is a combination of paraquat (Group 22) and S-metolachlor (Group 15). Upon EPA approval, it will provide two alternative sites of action to glyphosate

(Group 9) and has tank-mixture flexibility for multiple cropping systems.

A NEW RESIDUAL HERBICIDE FOR DICAMBA-TOLERANT SOYBEANS. Chad Asmus*[1], Kyle Keller[2]; [1]BASF Corporation, Newton, KS, [2]BASF Corporation, Raleigh, NC (184)

Tank-mixing Group 15 residual herbicides with postemerge applications of Engenia herbicide on dicamba-tolerant soybeans is an effective weed resistance management strategy, especially in regards to Amaranthus species. Growers and applicators will often prefer the convenience of a pre-mixture product as opposed to tank-mixing if the option is available. Trial data will be shared regarding a new pre-mixture herbicide from BASF of BAPMA-dicamba plus pyroxasulfone for dicamba-tolerant soybeans.

ENGENIA HERBICIDE RESEARCH UPDATE. Chad Asmus*[1], Sanjeev Bangarwa[2]; [1]BASF Corporation, Newton, KS, [2]BASF Corporation, Raleigh, NC (185)

Laboratory and field studies were conducted during 2018 to investigate possible causes of potential off-target movement of dicamba. Laboratory studies were conducted utilizing the Quantitative Humidome method. BASF also sponsored large-scale field trials in an effort to confirm the influence of proper application techniques (e.g. correct nozzles and boom height) and their influence on primary and secondary loss of dicamba.

DRY EDIBLE BEAN SENSITIVITY TO REDUCED RATES OF DICAMBA AND 2,4-D. Scott R. Bales*[1], Christy Sprague[2]; [1]Michigan State University, east lansing, MI, [2]Michigan State University, E Lansing, MI (186)

Sugarbeet producers reported waterhemp (*Amaranthus tuberculatus*) as their most important weed control challenge on 96,153 hectares or 34% of the sugarbeet area in eastern North Dakota and Minnesota according to a 2018 survey. The most frequently used waterhemp control program is layered application of chloroacetamide herbicides with glyphosate and ethofumesate when sugarbeet reach the two-leaf stage or greater followed by a repeat application 14 to 17 days later. There are occasions when waterhemp control is not complete, although 85% of producers reported good or excellent control with this program. Producers use desmedipham and phenmedipham, inter-row cultivation and/or hand-weeding to compliment the chloroacetamide herbicides weed management plan. Desmedipham and phenmedipham will not be available to producers once inventory is exhausted as registration was not renewed in 2014. Field experiments were conducted in 2016, 2017 and 2018 near Hickson, ND to evaluate crop tolerance with acifluorfen in environmental conditions to accentuate sugarbeet injury including timing of application, air temperature and humidity, and adjuvant. Acifluorfen plus crop oil concentrate (COC) postemergence at 0.28 kg ai ha^{-1} + 1.17 L ha^{-1} were applied under hot and humid conditions with a bicycle wheel plot sprayer delivering 159 L ha^{-1} at 276 kPa through 8002 nozzles when sugarbeet had two to four leaves. Results indicated acifluorfen reduced root yield and recoverable sucrose in two of three environments. Climate data suggests elevated air temperature and humidity contributed to increased efficacy and resulting loss of root yield and recoverable sugar. Acifluorfen at 0.28 kg ai ha^{-1} plus COC were applied when sugarbeet had 2-, 6-, 10-, and 10- to 12-leaves in 2018. Growth reduction injury decreased and necrosis injury increased as sugarbeet growth stage at application increased. Root yield and recoverable sucrose with acifluorfen treatments were less or tended to be less than the untreated and glyphosate controls. Root yield and recoverable sugar tended to increase as sugarbeet growth stage at acifluorfen application increased. These experiments demonstrate there might be sugarbeet selectivity to acifluorfen. However, additional experiments are needed to optimize application timing, adjuvant and environmental conditions at acifluorfen application.

CROP SAFETY FROM ACIFLUORFEN IN SUGARBEET. Tom J. Peters*, Alexa L. Lystad, Nathan H. Haugrud; North Dakota State University, Fargo, ND (187)

Sugarbeet producers reported waterhemp (*Amaranthus tuberculatus*) as their most important weed control challenge on 96,153 hectares or 34% of the sugarbeet area in eastern North Dakota and Minnesota according to a 2018 survey. The most frequently used waterhemp control program is layered application of chloroacetamide herbicides with glyphosate and ethofumesate when sugarbeet reach the 2-lf stage or greater followed by a repeat application 14 to 17 days later. There are occasions when waterhemp control is not complete, although 85% of producers reported good or excellent control with this program. Producers use desmedipham and phenmedipham, inter-row cultivation and/or hand-weeding to compliment the chloroacetamide herbicides weed management plan. Desmedipham and phenmedipham will not be available to producers once inventory is exhausted as registration was not renewed in 2014. Field experiments were conducted in 2016, 2017 and 2018 near Hickson, ND to evaluate crop tolerance with acifluorfen in environmental conditions to accentuate sugarbeet injury including timing of application, air temperature and humidity, and adjuvant. Acifluorfen plus crop oil concentrate (COC) postemergence at 0.28 kg ai ha^{-1} + 1.17 L ha^{-1} were applied under hot and humid conditions with a bicycle wheel plot sprayer delivering 159 L ha^{-1} at 276 kPa through 8002 nozzles when sugarbeet had two to four leaves. Results indicated acifluorfen reduced root yield and recoverable sucrose in two of three environments. Climate data suggests elevated air temperature and humidity contributed to increased efficacy and resulting loss of root yield and recoverable sugar. Acifluorfen at 0.28 kg ai ha^{-1} plus COC were applied when sugarbeet had 2-, 6-, 10-, and 10- to 12-leaves in 2018. Growth reduction injury decreased and necrosis injury increased as sugarbeet growth stage at application increased. Root yield and recoverable sucrose with acifluorfen treatments were less or tended to be less than the untreated and glyphosate controls. Root yield and recoverable sugar tended to increase as sugarbeet growth stage at acifluorfen application increased. These experiments demonstrate there might be sugarbeet selectivity to acifluorfen. However, additional experiments are needed to optimize application timing, adjuvant and environmental conditions at acifluorfen application.

THE INFLUENCE OF PLANTING DATE AND HERBICIDE PROGRAM ON LATE EMERGING WEEDS IN DRY BEAN. Clint W. Beiermann*[1], Cody F. Creech[1], Amit Jhala[2], Stevan Knezevic[3], Robert Harveson[1], Nevin C. Lawrence[4]; [1]University of Nebraska-Lincoln, Scottsbluff, NE, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]University of Nebraska, Wayne, NE, [4]University of Nebraska, Scottsbluff, NE (188)

Palmer amaranth is difficult to control in dry bean because of season-long emergence and resistance to ALS-inhibiting herbicides. Pre-plant incorporation (PPI) and pre-emergence (PRE) residual herbicide programs do provide excellent control, but only for a limited period of time. A study was initiated in 2017 and 2018 to investigate if delaying planting of dry bean would provide residual herbicide activity later into the season. The study was arranged as a split-plot RCBD, with planting date and herbicide treatment as main- and split-plot factors, respectively. Late planting occurred 15 days following standard planting. Herbicide treatments included imazamox (35 g ai ha^{-1}) + bentazon (673 g ai ha^{-1}) applied POST, pendimethalin (1070 g ai ha^{-1}) + dimethenamid-P (790 g ai ha^{-1}) applied PRE, EPTC (2950 g ai ha^{-1}) + ethalfluralin (1470 g ai ha^{-1}) applied PPI, pendimethalin + dimethenamid-P PRE followed by imazamox + bentazon, EPTC + ethalfluralin PPI followed by imazamox + bentazon, a non-treated check, and a hand weeded check. In both 2017 and 2018, Palmer amaranth density and biomass was lowest and crop yield was superior with EPTC + ethalfluralin fb imazamox + bentazon regardless of planting date. EPTC + ethalfluralin alone and pendimethalin + dimethenamid-P fb imazamox + bentazon provided similar weed control as EPTC + ethalfluralin fb imazamox + bentazon. In 2018 late planting provided superior biomass reduction from pendimethalin + dimethenamid-P alone and EPTC + ethalfluralin alone, as compared to standard planting. Delaying planting only provided yield benefits when pendimethalin + dimethenamid-P were applied alone in 2018.

AXIAL BOLD: THE NEXT STEP UP FOR GRASS CONTROL IN WHEAT AND BARLEY. Brett Miller*[1], Pete C. Forster[2], Don Porter[3], Monika Saini[3]; [1]Syngenta Crop Protection, Fargo, ND, [2]Syngenta Crop Protection, Eaton, CO, [3]Syngenta Crop Protection, Greensboro, NC (189)

Axial® Bold is a new selective herbicide developed by Syngenta Crop Protection for postemergence control of annual grass weeds in wheat and barley. The active ingredients contained in Axial Bold are pinoxaden and fenoxaprop-p-ethyl in a 2:1 ratio and they are formulated with the safener cloquintocet-mexyl and a built-in adjuvant. Axial Bold has good crop safety to all varieties of spring wheat, winter wheat and barley. Axial Bold is not approved for use on durum. Axial Bold can be applied from emergence up to the pre-boot stage of spring and winter wheat and emergence to prior to the jointing stage in barley. The use rate of 1.1 L ha^{-1} effectively controls wild oat (*Avena fatua*), foxtails (Setaria species), Italian ryegrass (*Lolium multiflorum*), Persian darnel (*Lolium persicum*), and barnyardgrass (*Echinochloa crus-galli*), as well as several other annual grasses. Axial Bold can be used in tank mixtures with broadleaf herbicides for flexible one-pass grass and broadleaf weed control in wheat and barley crops. Field results show that Axial Bold provides more consistent foxtail and barnyardgrass control and more consistent overall grass control when used in tank mixtures with broadleaf herbicides than competitive Group 1 and Group 2 graminicides. Based on its broad grass weed control spectrum, increased activity and consistency, flexibility of use, and crop safety, Axial Bold will become a new standard for grass weed control tool in wheat and barley crops. Axial

Bold is currently approved for use in all wheat and barley growing areas of the US and will be commercialized for the 2019 growing season.

INVESTIGATIONS OF THE SENSITIVITY OF VARIOUS TREE AND ORNAMENTAL SPECIES TO DRIFTABLE FRACTIONS OF 2,4-D AND DICAMBA. Brian R. Dintelmann*, Michele Warmund, Mandy Bish, Kevin W Bradley; University of Missouri, Columbia, MO (190)

The development and implementation of 2,4-D- and dicamba-resistant soybean and cotton has been driven by the increasing spread of herbicide-resistant weed species. Off-target movement of 2,4-D and dicamba is a major concern, especially for neighbors with sensitive crop or plant species. A study was conducted in 2017 and 2018 to determine the sensitivity of driftable fractions of 2,4-D and dicamba with or without glyphosate on common ornamental, shade, fruit, and nut trees, and berry species. Three driftable fractions corresponding to 1/2, 1/20 and 1/200 of the manufacture's full labeled rate (1X rate) of 2,4-D choline, 2,4-D choline plus glyphosate, dicamba, and dicamba plus glyphosate were applied to apple, crabapple, dogwood, elderberry, elm, grape, hydrangea, maple, oak, peach, pecan, redbud, rose, raspberry, strawberry, sweetgum, viburnum, and walnut plants that were contained in 10 to 20 L pots. The experimental design was arranged as a split-plot with five replications. Main plots consisted of plant species, while the sub-plots consisted of the herbicide treatments. Visual estimation of injury evaluations, change in trunk diameter and change in shoot length were recorded throughout the experiment. Data were analyzed using the PROC GLIMMIX procedure in SAS, and means were separated using Fisher's Protected LSD ($P<0.05$). There was a significant overall species by treatment by rate interaction. The 1/2X rates of all four herbicide treatments caused the greatest visual injury across species tested at 28 days after treatment (DAT). When averaged across years and species evaluated, the 1/2X rate of 2,4-D choline plus glyphosate resulted in 60% injury 28 DAT, while the 1/2X rate of dicamba plus glyphosate resulted in 50% injury. Peach and maple trees were the only species to have greater injury from dicamba plus glyphosate compared to 2,4-D choline plus glyphosate at the 1/2X rate, while grape, pecan, walnut, crabapple, rose, elm oak, and sweetgum had greater injury from 2,4-D choline plus glyphosate compared to dicamba plus glyphosate at the 1/2X rate. Based on the 1/20X rate of 2,4-D choline and dicamba alone, dogwood, elderberry, maple, oak, peach, redbud, and viburnum were more sensitive to dicamba than 2,4-D; conversely walnut trees were more sensitive to 2,4-D than dicamba. There were no differences in the sensitivity of apple, crabapple, elm, grape, hydrangea, pecan, rose, raspberry, strawberry, and sweetgum to either herbicide at the 1/20X rate. Percent change in trunk diameter was influenced most by applications of dicamba plus glyphosate at the 1/2X rate. When treatments containing 2,4-D were combined, grape, walnut, dogwood, elderberry, oak, viburnum, elm, and redbud experienced greater than 20% injury. Similarly, when treatments containing dicamba were combined, grape, elderberry, dogwood, peach, oak, viburnum, maple, and redbud had greater than 20% injury, indicating that these species are extremely sensitive to 2,4-D and dicamba, respectively. Results from this experiment indicate that there can be substantial injury to common ornamental, shade, fruit, and nut trees, and berry species, and that there are differences in the sensitivity of most of these species to 2,4-D and dicamba.

INTER-ROW CULTIVATION TIMING EFFECT ON SUGARBEET YIELD AND QUALITY. Nathan H. Haugrud*, Tom J. Peters; North Dakota State University, Fargo, ND (191)

The migration of glyphosate-resistant (GR) waterhemp (*Amaranthus tuberculatus*) into northern sugarbeet (*Beta vulgaris*) growing regions has made weed management in sugarbeet increasingly difficult in the past decade. Mechanical weed control methods such as inter-row cultivation were commonly used in sugarbeet until the release of GR sugarbeet cultivars in 2008 made the use of inter-row cultivation unnecessary. Survey data indicated that 99% of ND and MN sugarbeet hectares in 2007 were inter-row cultivated, but only 11% of hectares were cultivated in 2011 following the release of GR cultivars. Producers have renewed their use of inter-row cultivation to control weeds that glyphosate did/will not control, but historical data has shown risk for sugarbeet injury from cultivation. Past studies report that sugarbeet yield is negatively affected by numerous cultivations late in the season because of physical damage to root and foliar tissue, and soil-borne pathogens being deposited onto the sugarbeet crown. Field experiments were conducted on three locations in ND and MN in 2018 to evaluate the effect of inter-row cultivation timing on sugarbeet root yield, quality, and soil-borne disease infection. Cultivation was performed at 4- to 5-cm deep at 6.4 kph every two wk starting June 21 and ending August 16. Treatments were a combination of cultivation dates up to three passes and an untreated control. Sugarbeet stand density, root yield, and sucrose content were not affected by cultivation at any environment in 2018. Roots were visually inspected for soil-borne disease infection due to cultivation, but no infection was observed. Regression analysis to determine if sugarbeet yield or quality was affected by cultivation timing was not significant. The effect cultivation on sugarbeet yield is likely a complex interaction of cultivation procedures and environment, and experiments should be repeated in future years to determine how and when cultivation could affect sugarbeet yield.

GROWTH AND REPRODUCTIVE RESPONSE OF VIDAL BLANC GRAPES TO DICAMBA. Sarah E. Dixon*, Reid Smeda; University of Missouri, Columbia, MO (192)

Rising adoption of dicamba-tolerant soybeans increases the potential exposure of sensitive crops such as grapes to dicamba where off-target movement may occur via particle or vapor drift. In 2017 in Rocheport, MO and 2018 in Excelsior Springs and Augusta, MO, field research was established to determine the short- and long-term effects of dicamba on hybrid grapes (Vidal blanc). During flowering and early fruit set, established grapes were exposed to low rates of dicamba, delivered as a spray solution (36 or 72 ppm) or by vapor from treated soil. Throughout the growing season, plant injury and shoot length were recorded for selected shoots. For grapes exposed in both 2017 and 2018, injury symptoms (leaf cupping and feathering) were observed on grape shoots for both rates of particle and vapor drift at both application timings. Mean visual injury to growing shoots in 2018 was estimated to be 19-44% for plants exposed to vapor drift, and 53-72% for plants exposed to particle drift. For flowering grapes exposed to dicamba as particle drift in 2017, early-season shoot growth the following year was reduced by 30% as of May 15, 2018. Across both sites in 2018, exposure to particle drift of dicamba at 72 ppm reduced shoot growth by 10 and 100% at flowering and fruit set, respectively. Consistent with results from 2017, exposure to vapor drift of dicamba in 2018 increased shoot growth relative to controls, regardless of the timing of exposure. At harvest, grape yield and cluster weight were recorded. No differences were found for grape yield at harvest in 2018 for grapes exposed in 2017. Impacts of dicamba applied in 2018 on grape yield varied. A reduction of 33 to 58% was measured in Augusta for vapor exposure at early fruit set, but yields increased 15-20% for the same treatment in Excelsior Springs. Grape yields were reduced from 7 to 30% for particle and vapor drift during flowering in Excelsior Springs, but increased 4.5 to 90% for the same treatments in Augusta. Visual symptomology and reduction of shoot growth on grapes by dicamba occurs at low concentrations, but predictive impacts on grape yield is more complex and likely a combination of chemical, environmental, and cultural factors.

MAPPING OF GENES INVOLVED IN MESOTRIONE TOLERANCE USING BSR-SEQ IN GRAIN SORGHUM. Balaji Aravindhan Pandian*, Vara Prasad PV, Sanzhen Liu, Tesfaye Tesso, Mithila Jugulam; Kansas State University, Manhattan, KS (193)

Grain sorghum is one of the most versatile crops, which has the ability to produce high yields under limited water and other inputs. Control of weeds, especially postemergence (POST) grass species in grain sorghum is a major challenge across the US. Mesotrione is a broad-spectrum herbicide registered for use in corn, but not for POST application in sorghum due to crop injury. Our previous research identified two sorghum genotypes (G-1 and G-10) with elevated tolerance to mesotrione. However, the genetic basis of tolerance is unknown in these genotypes. To study the genetic control of mesotrione tolerance, reciprocal crosses using mesotrione-tolerant (G-1 and G-10) and -sensitive (S-1) genotypes of sorghum were performed, and the F1 seed were generated. The F1 progeny were evaluated in a mesotrione dose-response (0 to 8X of mesotrione; where X is 105 g ai ha^{-1}, which is the field used dose) assay. Further, the F2 seeds were also generated by self-pollinating the F1 progeny. Dose-response assay indicated that the F1 progeny from reciprocal crosses exhibited the same level of tolerance as tolerant parent, suggesting that mesotrione resistance in sorghum is controlled by a single dominant nuclear gene. Experiments are in progress to evaluate the F2 progeny and to map the gene controlling the mesotrione tolerance via bulk segregation analysis combined with RNA-Seq (BSR-seq). BSR-Seq technique greatly simplifies the cloning of causal genes.

ARE AD HOMINEM ARGUMENTS ABOUT FUNDING SOURCES CONSISTENT WITH SKEPTICAL INQUIRY? Allan Felsot*; Washington State University, Richland, WA (196)

Science policy regarding research has historically categorized the enterprise as basic or applied. I would argue that a continuum exists among the objectives of all research regardless of artificial categories. Nevertheless so-called applied research is more likely to be associated with some regulatory agency's domain. Such is the case regarding pesticide chemistry and toxicology research. Industries with vested financial interests are most likely to first report the synthesis and discovery of the properties of pesticidal molecules. The data seem initially hidden in patents but over the last several decades industry scientists have increasingly submitted studies about successfully commercialized products to peer reviewed journals. However, detailed summaries of industry studies required for human health and ecological protection are also publicly accessible in US EPA registration decision documents. Although transparency is increasingly facilitated by global access to digital resources, controversy over data quality and conclusion bias has grown in association with ad hominem attacks based solely on funding sources. If skeptical inquiry is practiced using good laboratory practices that promote intense quality control and assurance of appropriately designed studies, why should funding sources make a difference? After all, all peer review is based on trust that scientists are honest brokers unless proven to be fraudulent. An argument could also be made that scientists in general act independently without influence of funding sources. If the public in general and some advocacy scientists doubt the honesty and objectivity of industry-funded scientific studies, either supported directly in house or indirectly through consulting labs and university grants, then they are impugning their own integrity. For example, requests for grant/contract proposals have narratives that suggest that pesticides or some other environmental contaminants have adverse effects that need to be studied. The lion's share of the Federal grant dollars go to university laboratories with vested interest in studying and documenting mechanisms of possible effects without attention to exposure realism that is necessary for risk managers to make sound decisions. Is the university scientist therefore not also biased toward conclusions of imminent hazard because they know where their "bread is buttered" and face ceaseless pressures to garner the next grant award? Thus, the ad hominem attack that negatively criticizes research results and conclusions based on funding source is a slippery slope that impugns the integrity of all scientific inquiry. Perhaps an idealistic solution to eliminate bias based on funding sources would be to strip all author names and affiliations and funding descriptions during a blind peer review process so that only after publication is this information publicly presented.

INTERACTIONS WITH AGRICULTURE MEDIA. Pam Smith*; DTN/The Progressive Farmer, Decatur, IL (198)

This presentation will investigate the concepts of science communication and working with agricultural media. More than ever, weed scientists are being asked to provide assessments to non-scientists. Learn how journalists think and work and ways you can be a more effective communicator outside academic circles. The presentations will explore how the world of journalism is changing and how to cultivate media relationships you can trust. Pamela Smith has more than 40 years of experience in writing on agricultural topics and is the current Crops and Technology Editor for DTN and The Progressive Farmer, a national agricultural magazine.

DEW INCREASES DICAMBA VOLATILITY FROM SOYBEAN. Jerri Lynn Henry*, Reid Smeda; University of Missouri, Columbia, MO (200)

Widespread use of dicamba on dicamba-tolerant soybean has resulted in reports of off-target movement affecting many areas nationwide. The underlying cause of movement in some cases has been attributed to weather related phenomena such as temperature inversions. However, little to no research has been conducted on another commonly occurring environmental phenomenon such as dew formation. Soybeans were exposed to labeled rates of dicamba (0.68 kg ae ha^{-1}) and herbicide solutions were allowed to dry. Some soybean plants were then placed directly into a sealed polyethylene box connected to an air sampler, coupled with a PUF tube, in a growth chamber simulating summer conditions (29 C daytime and 23.9 C nighttime/ 16 hour photoperiod). For other soybean plants, dew was allowed to form over three hours under humid conditions and plants were then moved to identical environmental conditions in a separate polyethylene box, as described above. Soybeans were evaluated for 48 hours after treatment (HAT), replacing the PUF tube every 24 hours. Dicamba was extracted using methanol and quantified using LCMS. Dicamba concentrations found in air samples were 20% higher for soybeans displaying dew after dicamba exposure ($p > 0.02$), compared to dry soybeans. Soybeans previously exhibiting dew continued to display increased dicamba volatilization up to 48 HAT.

Formation of dew may play an important role in influencing the fate of dicamba on treated plants.

HERBICIDE RESISTANCE MECHANISMS INFORM HERBICIDE RECOMMENDATIONS FOR MARESTAIL CONTROL. Sarah Miller*[1], Marisa DeForest[2], John Pauley[2], Clint Meyer[1]; [1]Simpson College, Indianola, IA, [2]Simpson college, Indianola, IA (202)

Due to diverse biochemical processes, herbicide resistance has become common in many agricultural weeds. While it is clear that many weeds have numerous resistances, it is important to understand the cause and mechanism so that we are able to address this evolving concern. In order to gather a better understanding of how these resistances work at the cellular level, we investigated the processes of herbicide resistance in marestail, more specifically glyphosate resistance. Through the examination of the glyphosate-resistance pathway in marestail, we are able to relate this resistance to other potential resistances in the future. By comparing the pathways of herbicides with similar mechanisms, we can hypothesize potentially related resistances and their emergence in the future. We will then be able to provide a recommendation for further herbicide application based on chemicals whose pathways are easily manipulated in order to avoid further resistance. Initiating this recommendation, we examined the active ingredients of various herbicides in relevant BASF herbicides. By identifying these active ingredients along with their main pathways, we can identify the ingredients whose pathways will be most likely to quickly form a resistance. Thus, we will be able to identify herbicides with active ingredient pathways that will likely prolong the onset of herbicide resistance in the future.

INHERITANCE OF MULTIPLE HERBICIDE RESISTANCE IN PALMER AMARANTH (*AMARANTHUS PALMERI*). Chandrima Shyam*[1], Sridevi Nakka[1], Karthik Putta[1], Ivan B. Cuvaca[1], Randall S Currie[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Garden City, KS (203)

Palmer amaranth (*Amaranthus palmeri*), is one of the most troublesome weeds in the US, which has evolved resistance to six herbicide modes of action. A population of Palmer amaranth in KS was found to have evolved resistance to three commonly used herbicides, i.e., ALS-, PS-II-, and HPPD-inhibitors. Our previous research indicated that the multiple-herbicide resistance in this Palmer amaranth population is primarily bestowed as a result of rapid metabolism of these herbicides, although a small percentage of plants also showed target-site alteration in the ALS gene and increased expression of the HPPD gene. To understand the genetic basis, in this research we investigated the inheritance of multiple herbicide resistance in this Palmer amaranth population. F1 progeny were produced by crossing plants that were previously confirmed to be resistant to ALS-, PS-II, and HPPD-inhibitors separately with known susceptible (to all three herbicides) Palmer amaranth plants. The F1 progeny, along with parental plants were used in ALS-(chlorsulfuron), PS II-(atrazine) and HPPD-(mesotrione)-inhibitor dose-response experiments to determine the degree of dominance of the genes conferring resistance. Further, two to four survivors (additional plants) of F1 dose-response study were used to generate F2 progeny, which were also evaluated for their response to the above three herbicides. The segregation of resistance and susceptible phenotypes was assessed in the F1 and F2 progeny. The results of F1 dose-response experiments and chi-square analyses of F2 segregation data suggested that the Palmer amaranth resistance to chlorsulfuron is controlled by a single dominant gene, while atrazine resistance is governed by an incompletely dominant gene. Resistance to mesotrione was found to be polygenic in nature. Single gene resistance can spread rapidly both via pollen and seed parent. While multiple gene traits may be slow to evolve but can confer resistance to unknown mode of action of herbicides. Regardless promotion of integrated weed management strategies can minimize the spread of resistance.

ANALYSIS OF THE TRANSCRIPTOME FOLLOWING 2,4-D TREATMENT IN SUSCEPTIBLE AND TOLERANT RED CLOVER (*TRIFOLIUM PRATENSE*) LINES. Lucas P. Araujo*[1], Michael Barrett[1], Linda D. Williams[1], Gene Olson[1], Randy Dinkins[2], Troy Bass[2]; [1]University of Kentucky, Lexington, KY, [2]USDA-ARS-FAPRU, Lexington, KY (205)

Incorporation of a legume, such as red clover (*Trifolium pratense*), into grass-based pasture systems, offers many benefits. However, available red clover lines are highly susceptible to herbicides, in particular, 2,4-D (2,4-dichlorophenoxyacetic acid), which has been widely used for broadleaf weed management in pastures. A novel red clover line, UK2014, was developed at University of Kentucky through conventional breeding and expresses higher tolerance to 2,4-D than Kenland, a common variety used by Kentucky's forage producers. Next generation sequencing (NGS) provides a novel and powerful tool to analyze the mechanisms of herbicide resistance. In this context, this study utilized an NGS approach to detect differential gene expression between UK2014 and Kenland following 2,4-D treatment, in a field setting. Objectively, this approach intended to uncover the genetic basis of the increased 2,4-D tolerance in the UK2014 red clover line. Both UK2014 and Kenland lines were grown in field studies at the University of Kentucky's Spindletop research farm. Plots of each line were treated with either 0 or 1.12 kg ae ha^{-1} of 2,4-D amine. Composite samples of ten leaflets from each plot were collected at 4, 24 and 72 hours after treatment (HAT). RNA sequencing was performed in the NGS Illumina HiSeq 2500 with 100 bp single reads. The reads were mapped against the *T. pratense* genome and read counts were obtained by the CLC workbench. The read counts were submitted to TMM normalization and analyses of variance in JMP genomics. A false discovery rate of 0.05 (FDR = 0.05) was set as the threshold for differential expression. The online tool AgriGO provided the gene ontology of the differentially expressed transcripts. Time of sampling (HAT) and 2,4-D treatment were the major fixed components of the variance, and cultivar displayed less of an effect. A significant number of these (997 out of 2217 contigs) was found to be upregulated in both UK2014 and Kenland following 2,4-D treatment. From these upregulated contigs, 50 were annotated as cytochromes P450 and glucosyl-transferases, enzymes commonly related to herbicide metabolism. Moreover, gene ontology of the differentially expressed contigs indicated a major relationship to biological processes such as responses to stimulus, stress, and metabolic processes. These results altogether provide an indication of the processes involved in the increased UK2014 tolerance to 2,4-D, although further validation is still necessary.

MONITORING GARLIC MUSTARD IN MINNESOTA - NOW YOU SEE THEM, NOW YOU DON&RSQUO;T. Roger Becker*[1], Laura Van Riper[2], Lori Knosalla[3], Rebecca Montgomery[4], Mary Marek-Spartz[3], Elizabeth Katovich[3]; [1]University of Minnesota, St Paul, MN, [2]Minnesota Dept. of Natural Resources, Saint Paul, MN, [3]University of Minnesota, St. Paul, MN, [4]Universiy of Minnesota, St. Paul, MN (206)

We will discuss issues with long-term monitoring of invasive plant populations that are seedbank driven annual or biennial systems. Our long-term monitoring of the biennial garlic mustard [*Alliaria petiolata* (M. Bieb.) *Cavara & Grande*] has experienced several challenges with populations expressing in different areas on the landscape, often decreasing in permanent quadrats established at 12 long-term monitoring sites in 2005 or 2006, while populations are flourishing nearby. In the fall of 2017, we explored using EDDMapS/GLEDN and ISMTrack at five of these long-term monitoring sites to characterize garlic mustard populations on a broader scale. In 2018, we tested a small plot design and data collection efficiencies, looking for more meaningful techniques to characterize populations of garlic mustard over time. Lessons learned from these contrasting approaches will be presented.

THE INFLUENCE OF SOIL FERTILITY AND PH ON PASTURE WEED OCCURRENCE. Gatlin E. Bunton*, Kevin W Bradley; University of Missouri, Columbia, MO (207)

Approximately 25% of agricultural land in Missouri is utilized for pasture and forage production. Weeds are the primary pest of pastures and can result in reductions in forage yield and cattle utilization. A survey of 66 Missouri pastures was conducted in 2015, 2016, and 2017 to determine the prevalence of weed species across the state and to investigate the influence of soil fertility and pH on weed incidence. At each location, one 20-m^2 area was surveyed for every four ha of pasture, and each sampling area was visited at two-wk intervals from April through September. Weed and forage species, density and height were recorded at each location at every survey timing. Soil samples were collected from each survey area to determine soil pH, soil phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sulfur (S), zinc (Zn), manganese (Mn), and copper (Cu) levels. Linear regression analyses were conducted determine the relationship between weed density and soil pH and nutrient levels. The most common weeds encountered in Missouri pastures were horsenettle (*Solanum carolinense* L.), common ragweed (*Ambrosia artemisiifolia* L.), sedge species (Carex,/Cyperus spp.), yellow foxtail (*Setaria pumila* Poir.), dandelion (*Taraxacum officinale* F.H. Wigg.), broadleaf plantain (*Plantago major* L.), vervain species (Verbena spp.), annual fleabane (*Erigeron annuus* L.), tall ironweed (*Vernonia gigantea* Trel.), and large crabgrass (*Digitaria sanguinalis* L.). Annual and perennial broadleaf weeds were the most prevalent and densities increased from spring to mid-summer. Results from the soil analysis indicate that for every part per million (ppm) increase of potassium and zinc, and for every one unit increase in soil pH, there was a decrease of 10, 110, and 2,521 annual broadleaf weeds ha^{-1}, respectively. Perennial broadleaf weeds were also reduced by increases in soil potassium and manganese levels. Conversely, annual grass weed density increased by 231 and 265 weeds ha^{-1} with a one ppm increase in manganese or zinc. The results of this study indicate that some of the most common annual and perennial broadleaf weeds that occur in Missouri pastures may be reduced through proper management of soil fertility and pH.

HOUSING DEVELOPMENT IMPACTS ON HERBICIDE RESISTANT WEED PRESSURE AND PRODUCTIVITY POTENTIAL: A CASE STUDY IN WARREN COUNTY, IOWA. Laken Baird*[1], Drew Roen[1], Clint Meyer[1], John Pauley[2]; [1]Simpson College, Indianola, IA, [2]Simpson college, Indianola, IA (208)

Many rural areas in Iowa are experiencing increased encroachment from urban development. This creates many interfacing areas between agricultural production and housing. This, in turn, creates challenges related to herbicide drift, movement of large equipment, and lack of weed management during transitional phases of land use. Warren County, Iowa is a largely rural county with multiple areas experiencing increased development driven by proximity to the Des Moines metropolitan area. Our objective was to assess impacts of development on weed infestation and herbicide resistance. We surveyed multiple townships in the county experiencing either high or low development pressure. We identified areas with high weed infestation (>15%), recorded prominent weed species, and estimated aerial coverage of each weed species (in particular, giant ragweed, waterhemp, and marestail). We found that townships with high rates of urban development also had much higher rates of weed infestation. This problem is likely to increase as development in this and other areas of the state continue to see urban expansion.

CONTROL OF SALTCEDAR USING HERBICIDES. Walter H. Fick*; Kansas State University, Manhattan, KS (209)

Saltcedar (*Tamarix ramosissima*) is a woody invasive species found in Kansas primarily along major watersheds including the Cimarron, Arkansas, Smoky Hill, and Republican rivers. The objective of this study was to compare the efficacy of five herbicides applied for saltcedar control. The study site was located on the Cimarron National Grasslands near Elkhart, KS. Three herbicides were applied with a backpack sprayer at 467 L ha^{-1} total spray solutions with the addition of either a 1% v v^{-1} methylated seed oil or a 0.25% v v^{-1} non-ionic solution. A basal treatment of 48 g L^{-1} triclopyr in diesel was also applied. Herbicides were applied on September 11, 2017 with 12 to 22 trees treatment^{-1}. Saltcedar mortality was determined the growing season after application. Chi square analysis was used to determine differences among treatments at the 0.05 level of probability. Imazapyr at 2.4 g L^{-1}, a combination of imazapyr + glyphosate at 1.2 + 2.7 g L^{-1}, and imazapic at 2.4 g L^{-1} provided 100% control of saltcedar. Aminopyralid + triclopyr (0.3 + 3.6 g L^{-1}) provided only 22% mortality. The triclopyr in diesel treatment (48 g L^{-1}) provided 100% control. The aminopyralid + triclopyr treatment was ineffective despite above normal precipitation in August and September.

FIELD VALIDATION OF 15 INVASIVE PLANT ENSEMBLE HABITAT SUITABILITY MODELS IN WISCONSIN USING CITIZEN SCIENCE OBSERVATIONS. Niels A. Jorgensen*[1], Mark Renz[2]; [1]University of Wisconsin, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI (210)

Terrestrial invasive plants are a widespread and pervasive problem in the US. In the state of Wisconsin alone, over 140 plant species are regulated. The large number of species make it challenging for individuals to monitor for all species. Land managers have requested a spatially explicit tool to assist in prioritizing monitoring efforts. Using data through 2016, we developed ensemble habitat suitability models (HSMs) for 15 species in the state of Wisconsin at a 30-m spatial resolution using common environmental, climatic and topographic predictor layers. The ensemble was comprised of boosted regression trees, generalized linear models, multivariate adaptive regression splines, MaxEnt, and random forests. Models were assessed for predictive performance (AUC, Cohen's Kappa, True Skills Statistic, etc.) and overfitting (difference between training and cross-validation testing metrics). Any poorly performing models were either tuned or eliminated from the study. To validate the accuracy of these models to predict suitable habitat, we engaged stakeholders from 2017 – 2018 to report invasive plants to the online database EDDMapS (Early Detection and Distribution Mapping System). As a result, 5,005 reports for these 15 species were submitted from 96% of counties. We used this independent dataset to evaluate model accuracy in predicting presence. Models for the 15 species correctly classified suitable habitat for 83% of all new reports, with eight of the 15 species correctly classifying suitable habitat 80% of the time. All models had AUC values of 0.7 or greater, but higher AUC values were not necessarily associated with better suitable habitat classification rates. For example, autumn olive (*Elaeagnus umbellata*) had AUC values of 0.85 - 0.92, but classified suitable habitat only 56.4% (n=454) of the time. Wild parsnip (*Pastinaca sativa*) had similar AUC values (0.84 - 0.95), but was able to classify suitable habitat 97% (n=365) of the time. Results suggest that while traditional model metrics are useful in assessing performance, field validation should be conducted to ensure performance. Use of verified observations from existing networks can be an effective means at conducting field validation.

CURRENT DISTRIBUTION, SUITABLE HABITAT, AND CONTROL OF COMMON VALERIAN (*VALERIANA OFFICINALIS* L.) IN WISCONSIN. Mark Renz*[1], Niels A. Jorgensen[2]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin, Madison, WI (211)

Common valerian (*Valeriana officinalis* L.) is a regulated invasive perennial plant that invades grassland habitats including pastures and roadsides/right-of-ways in Wisconsin. Currently over 1,000 locations are known, with >95% found in Northern Wisconsin. While populations are expanding rapidly in northern Wisconsin it is unclear if populations will be invasive in southern portions of the state. To address this question we developed ensemble habitat suitability models (HSMs) from 2016 data in the state of Wisconsin at a 30-m spatial resolution using common environmental, climatic and topographic predictor layers. The ensemble was comprised of boosted regression trees, generalized linear models, multivariate adaptive regression splines, MaxEnt, and random forests. Models were assessed for predictive performance (AUC, Cohen's Kappa, True Skills Statistic, etc.) and overfitting (difference between training and cross-validation testing metrics). Any poorly performing models were either tuned or eliminated from the study. Results found models performed well with AUC values > 0.89. The ensemble map shows wide agreement in suitable habitat in northern Wisconsin where populations are widely distributed as well as eastern portions of Wisconsin near the Lake Michigan shoreline where < 30 populations are known. Predictor layers that were driving model performance were spring and summer precipitation and % clay in the soil. We also evaluated common pasture/grassland herbicides to evaluate effectiveness in control. Applications of 2,4-D (1.06 kg ae ha^{-1}), aminopyralid (0.12 kg ae ha^{-1}), clopyralid (0.56 kg ae ha^{-1}), dicamba (1.12 kg ae ha^{-1}), metsulfuron (0.42 kg ae ha^{-1}), or triclopyr (1.12 kg ae ha^{-1}) were broadcasted onto fall to rosettes resprouting following mowing. The following summer (9.5 months after treatment) metsulfuron provided > 90% reduction in cover compared to untreated controls. While other treatments also showed suppression compared to the untreated control, reduction with other active ingredients never exceeded 70%. Results remained consistent 12 months after treatment. Results from these efforts suggest that common valerian has the potential to continue to spread in Wisconsin. In grassland situation that common valerian invades, initial results suggest that herbicides that contain metsulfuron are effective at providing long-term control. Future studies are required to confirm these results.

ATMOSPHERIC CONDITIONS FOR ON-TARGET APPLICATIONS: INTRODUCTION. David Simpson*; Corteva Agriscience, Zionsville, IN (212)

Atmospheric conditions at the time of a herbicide application have impact physical drift from herbicide applications. Increased downwind drift with increasing wind speed is a well understood principle by the agricultural community, and thus to avoid physical drift, herbicide applications are commonly made when wind speeds are low. When wind speed is less than 4.8 kph, some herbicide labels state that applications should not be made if a temperature inversion is present. Temperature inversions are not well understood in the agricultural community. Recent research data has indicated that temperature inversions may be more common, develop earlier in the day and persists for longer time periods than previously thought. To provide applicators with a means to determine if temperature inversion is present, various tools from smartphone apps, websites, and handheld measuring devices have been developed recently by public and private sectors. The weed science and the agricultural community generally lacks understanding of weather data sources and predictive modeling for wind speed and temperature inversions. Making decision on whether atmospheric conditions are favorable for on-target applications requires applicators to have accurate data on wind speed, wind direction and the presence or potential formation of a temperature inversion. This symposium on Atmospheric Considerations for Making On-Target Applications seeks to bring perspectives from experts within and outside the weed science community to improve the understanding of temperature inversions, sources for weather data, wind speed and direction, measurement tools for temperature inversions, and particle drift in presence and absence of a temperature inversion. A multi-discipline perspective will be required to advance our ability to forecast and identify the presence of a temperature inversion and create notification systems which will allow applicators to avoid applying during a temperature inversion.

A FACT CHECK OF TEMPERATURE INVERSION UNDERSTANDING. Vernon Hofman*[1], Andrew A. Thostenson[2]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, Fargo, MN (213)

Since 2010, North Dakota State University has actively pursued a greater understanding of air temperature inversions. Our early work focused mostly on assembling and interpreting known meteorological research and pesticide application research. We quickly realized little information could be found and most was not collated into any organized publication that was available to pesticide users. In 2014 we published an extension circular, "Air Temperature Inversions Causes, Characteristics and Potential Effects on Pesticide Spray Drift" (AE1705). Since that time we have printed 60,000 hard copies with a higher number of downloads via the world wide web (www). As a consequence, our North Dakota Agriculture Weather Network (NDAWN) initiated plans to retrofit weather stations with instrumentation to monitor and report inversions in real time on the www. The data collected measures the spread between a temperature sensor at three m and one m. Measurements are logged and reported in five min increments. In 2017, during the pesticide application use season, we had 11 stations on-line. That number grew to 41 in 2018. In June of 2018 we also rolled out a smartphone app that is available for Android and iPhone. "NDAWN Inversion APP" provides users real-time monitoring for inversions and alerts are available for all 41 locations. Observing air temperature inversions on such a vast scale has resulted in some interesting revelations and we will share them in this session.

NAVIGATING THE MAZE OF WEATHER DATA SOURCES AND AVOIDING PITFALLS. Dennis Todey*; USDA-ARS-NLAE, Ames, IA (214)

The creation of readily available monitoring equipment has greatly increased the data available to producers throughout the country. Federal, state, and private entities have increased the collection of data along with the provision of data, and a wide number of web sites, apps and social media provide something that "looks" like data. But is all that data good? What is actually measured data and what is synthetic? In this session we will review some issues about data and data sources, what good information is and what to watch out for. These issues are particularly important when documenting for drift purposes and a myriad of other potentially legal issues.

A METEROLOGIST PERSPECTIVE ON KANSAS MESONET INVERSIONS. Christopher Redmond*; Kansas State University, Manhattan, KS (215)

Kansas Mesonet began measuring inversions in mid-2017. Since then, data has been collected at 2.5 and 10 m at all tower locations which is about half of the 60 station network. The main focus of the inversion monitoring on the network is a bit different than others. Despite most of stations meeting World Meteorological Organization siting standards, the network isn't measuring below 2.5 m due to the microscale influences. In this presentation, we will discuss these observed localized influences. We will also explain why we provide data with emphasis on region wide measurements of a mesonet. Lastly, we will analyze trends and the resulting messaging to sprayers to avoid off-target drift issues.

TEMPERATURE INVERSION FINDINGS FROM A MULTI-STATE WEED SCIENCE PROJECT. Kevin W Bradley*, Mandy Bish; University of Missouri, Columbia, MO (216)

Surface temperature inversions occur when air nearest the earth's surface is cooler than the air above it; they create a stable atmosphere that is conducive for herbicide volatilization. Previous research has been conducted since 2015 to monitor the frequency and duration of inversions across three distinct geographies in Missouri. However, to monitor surface temperature inversions across a broader geography, similar weather stations were established in 2018 in Arkansas, Illinois, Indiana, Missouri and Tennessee. Temperatures were measured at heights relevant to ground pesticide applications: 18", 66", and 120" above the surface. Preliminary analysis of the data from June and July in Illinois, Indiana, Tennessee, and Missouri indicates that inversions were common and occurred across all sites on 43% of the evenings, although there were differences in the frequency of inversions between locations. Across all the 16 locations included in the project, Inversions began forming from 16:15 to 20:30 in June with an average start time of 18:34. In July, inversions began forming from 15:50 to 21:25 with an average start time of 19:02. Across all locations, inversions typically lasted 10 to 12 hours in June but were noticeably shorter at most locations in July. Similar observations were observed in data collected from three locations in Missouri from 2015 to 2017. Additional data pertaining to the effect of topography on inversions will be discussed. Preliminary results of this research support the importance of using new, low-volatile formulations of 2,4-D and dicamba to help minimize the potential impact of temperature inversions on volatilization of these active ingredients.

WHAT'S BEHIND SMARTPHONE TEMPERATURE INVERSION APPS. Eric Snodgrass*; University of Illinois, Urbana, IL (217)

Herbicide drift issues over the last few growing seasons have prompted many ag tech companies to develop temperature inversion prediction models. Many of these models make use of the high spatial and temporal resolution numerical weather prediction models created by the National Center for Environmental Predictions (NCEP) to forecast the time and depth of temperature inversions across the US. This presentation will focus on how hourly and sub-hourly numerical models are used to forecast inversions and near-surface wind speeds. Challenges in predicting the depth and duration of temperature inversions are largely a consequence of model resolution and terrain, but across much of the US agricultural landscape, these models perform well in capturing the behavior of the atmospheric boundary layer. While more research is needed to verify these predictions and add ground truth, these smartphone applications are providing producers with the best possible forecasts of near-surface wind speeds and inversion conditions.

GROUND-TRUTHING SMARTPHONE TEMPERATURE INVERSION AND WIND SPEED APPS. Joe Ikley*, William G. Johnson; Purdue University, West Lafayette, IN (218)

Pesticide record keeping has come under increased scrutiny recently following unprecedented numbers of herbicide drift complaints in many states in 2017 and 2018. Specifically, weather conditions during herbicide application are of great interest and concern to pesticide manufacturers and regulatory agencies. Following the 2017 growing season, the US EPA revised the labels for Engenia, FeXapan, and Xtendimax, the three dicamba products with approved over-the-top use in dicamba-tolerant soybean. Critical record-keeping components on these revised labels include the wind speed and direction, and presence/absence of a temperature inversion during application. Specifically, applicators must record these data at boom height at the beginning and end of every application. Several smartphone apps or websites have been developed recently in order to help applicators make decisions about the best times to apply pesticides. Several of these apps use GPS data to triangulate the user's position and attempt to predict the presence of a temperature inversion in the area, and also the wind speed at boom height. Engenia Spray Tool and the RRXtend app were developed specifically to help provide weather information and assist with decision making about the best times to apply new dicamba formulations. The wind speeds reported by several weather apps and websites were compared against measurements taken at boom height in a field near West Lafayette, Indiana during the 2018 growing season. Three apps that predict temperature inversion were also compared to in-field temperature inversion measurements. Wind speed and temperature inversion data from Indiana will be presented during this talk, as well as a comprehensive analysis of temperature inversion data from Missouri.

REGULATORY CHALLENGES OF INTERPRETING & DOCUMENTING WIND SPEED LANGUAGE ON LABELS. Dave Scott*; Office of Indiana State Chemist, West Lafayette, IN (219)

For over 40 years now, pesticide regulatory state lead agencies (SLAs) have been on the front lines of responding to reports and complaints of pesticide misuse and off-target movement. In most states, and particularly major agricultural production states, pesticide off-target movement is the number one complaint generator annually. Off-target movement complaints in 2017 and 2018 were certainly no exception to that trend. Record numbers of "drift" complaints were filed in many states, largely as the result of the federal approval of new dicamba product uses on dicamba-tolerant (DT) soybeans and cotton. Now, as in years past, product label interpretation has been a cornerstone of pesticide drift complaint response by SLAs. Pesticide registrants and US EPA have created a legacy of oftentimes vague and unenforceable use directions and restrictions on pesticide products, relative to management of drift and other off-target movement. Although such historically vague label statements such as "do not apply under windy conditions," and "do not apply under conditions that favor drift" are slowly being replaced on some labels with specific wind speed and wind direction restrictions, an SLAs ability to demonstrate that specific label restrictions were violated can still be very challenging and may sometimes be subject to dispute. During this session we will share some of the challenges faced by SLAs to interpret, apply, and enforce these weather-related label restrictions that can or may result in off-target movement.

DEPOSITION AND DISPERSION OF SPRAY DROPLETS IN NORMAL CONDITIONS. Jerome J. Schleier*; Corteva Agriscience, Indianapolis, IN (220)

The deposition and drift of agricultural sprays is dependent on many factors. A review of how a droplet is formed and the physics of particle movement after formation to the target surface and how downwind deposition changes with particle size. Additionally, will provide insight into how relative humidity, air temperature, wind speed, and turbulence affect the movement of spray droplets.

DISPERSION OF PARTICLES IN TEMPERATURE INVERSIONS. David Kristovich*[1], April Hiscox[2], Junming Wang[3]; [1]University of Illinois, Urbana, IL, [2]University of South Carolina, Columbia, SC, [3]ISWS, Prairie Research Institute, Champaign, IL (221)

Time periods when the atmosphere near the ground is stable (especially when temperature inversions are present) are targets for using airborne and surface equipment to apply herbicides. It is often considered that when a temperature inversion is present, not only is vertical dispersion of herbicides inhibited, but less inadvertent drift will occur due to weaker wind speeds. However, assuming that winds will be light when stable conditions are predicted can be incorrect and lead to costly decisions. In fact, conditions leading to surface temperature inversions can be ideal for the development of “air drainage flows” that can cause considerable herbicide drift. This presentation will outline questions about dispersion in stable atmospheric conditions and when air drainage might occur. Emphasis will be placed on new observations taken during the Stable Air Variability and Transport field project which was funded by the National Science Foundation and took place over the last couple months in Champaign County, IL. Dispersion and airflow in stable conditions was observed using instrumentation on towers, air particle counters, an acoustic sodar, aircraft, three LiDARs and other systems.

WEED ECOLOGY. Anita Dille*; Kansas State University, Manhattan, KS (224)

There are so many interesting research questions in weed science. Before being able to analyze data collected in an experiment, one must have a very clear question, then propose a hypothesis and design an appropriate study to answer the question. In weed ecology, we are trying to understand the biology of a given weed species, and its interaction with the environment including natural or agricultural systems. Typical examples of data that might be collected are discrete counts, continuous growth measurements, or treatment responses through time. Often these data do not follow normal distributions that meet assumptions of many traditional statistical tests, such as seedling count data in surveys, counts of seed or seedlings through time to document seed losses from the seedbank or emergence profiles as weed seed germinate. Different data types and experimental designs provide challenges to determining the most appropriate statistical analysis, methods of presenting data, and interpretation of the results. Some typical examples, good and not so helpful, will be reviewed.

Author Index

Ackley, Bruce A.	6, 40, 137
Adler, Renee L.	3, 194
Anderson, Ely	10
Anderson, Tim	182
Araujo, Lucas P.	205
Arsenijevic, Nikola	16, 49, 95, 146, 177
Asmus, Chad	184, 185
Atherton, Daniel L.	52
Bagavathiannan, Muthukumar	131
Baird, Laken	208
Bales, Scott R.	4, 43, 186
Bangarwa, Sanjeev	185
Barbosa dos Santos, Jose	50
Barenkow, Dave	32
Barfknecht, David F.	76
Barker, Abigail	152
Barlow, Blake R.	154
Barnes, Ethann R.	27, 44, 46, 61, 164
Barrett, Michael	33, 205
Bass, Troy	205
Becker, Roger	34, 35, 36, 206
Beckett, Tom	181
Behnken, Lisa M.	63, 106, 107, 110
Beiermann, Clint W.	61, 188
Bemm, Felix	17
Benoit, Lauren	158
Bernards, Mark L.	29, 52, 72
Bish, Mandy	65, 151, 176, 190, 216
Bissell, Daniel C.	94, 119
Boles, Lee A.	94, 100
Borgato, Ednaldo A.	67, 159
Bowers, Dane L.	161, 183
Bradley, Kevin W	53, 65, 151, 176, 190, 207, 216
Breitenbach, Fritz	63, 107
Brooker, Aaron P.	20, 26
Brown, Patrick	73
Brown Johnson, Ashli	127
Bunton, Gatlin E.	207
Burns, Erin E.	140
Burr, Chuck	22
Butts, Liberty E.	21, 146, 170
Butts, Thomas R.	10, 122, 177
Came, Dakota	13, 45
Canella Vieira, Bruno	10, 11, 51, 92, 102, 103, 104, 122, 139, 174
Carmody, Colton P.	83
Ceperkovic, Isidor	97, 98
Chahal, Parminder	42, 44, 175
Chaudhari, Sushila	7
Chiaranda Rodrigues, Camila	99, 101, 124
Chiaranda Rodrigues, Camila	104
Chism, Luke	79
Christoffers, Michael J.	15
Clark, Andrea	94, 100
Clark, Kerry M.	24, 172
Claussen, Steve W.	121
Coburn, Carl W.	175
Collins, Ryan J.	77
Conley, Shawn P.	37, 177
Constine, Adam L.	26
Cortat, Ghislaine	36
Coura Oliveira, Maxwel	16, 49, 50, 95, 108, 177
Creech, Cody F.	21, 22, 170, 188
Crosby, Kevin	182
Curlett, Heather	37
Currie, Randall S	130, 171, 203
Cuvaca, Ivan B.	130, 203
da Cunha, Joao Paulo R.	92
Dahl, Gregory K.	94, 100, 119, 163
Davis, Adam S.	160
de Oliveira Rodrigues, Andre	10, 122
De Souza Vieira, Gustavo	16, 146
de-Avellar, Matheus	146
Decker, Madison	68
DeForest, Marisa	202
Delucchi, Tomas F.	93
DeSimini, Stephanie	88, 142
DeWerff, Ryan P.	85, 95
Dille, Anita	71, 79, 80, 81, 138, 173, 224
Dinkins, Randy	205
Dintelmann, Brian R.	190
Dintelmann, Sarah J.	86
Dixon, Sarah E.	192
Dobbels, Anthony F.	39, 40
Dodds, Darrin	127
Dotray, Peter A.	131

Dunne, Cheryl L. 161
Edwards, Ryan J. 94, 100, 163
Ellis, Christine 167
Elmore, Roger 21, 22, 170
Evans, Cody 117
Farr, Rodger 14
Farrell, Shea T. 65
Felsot, Allan 115, 196
Fick, Walter H. 209
Fiery, Mike 128
Fisher, Justine 4
Forster, Pete C. 189
Franssen, Aaron 181
Fritz, Bradley K. 127
Gage, Karla L. 68, 76, 81, 83, 86
Gaines, Todd 152, 201
Gastler, Lindsey 71
Gednalske, Joe V. 119, 163
Gehling, Jamie 63
Geier, Patrick 171
Giacomini, Darci 16, 17, 73, 134, 226
Gifford, James 32
Gillilan, Jo A. 163
Gizotti de Moraes, Jesaelen 14, 90, 91, 124
Goley, Michael 167
Golus, Jeffrey 10, 11, 14, 51, 64, 97, 98, 99, 101, 122, 127, 139, 174
Gonzini, Lisa 160
Goplen, Jared J. 105, 106
Green, J D 156
Grint, Kolby R. 111
Haarmann, Jesse A. 69, 132
Hager, Aaron 89, 118, 160
Hamrock, Joseph 84
Haramoto, Erin 77, 78, 81
Harrison, Kent 31
Harveson, Robert 188
Haugrud, Nathan H. 187, 191
Hauver, Amy D. 46
Hay, Marshall M. 45, 173
Hayden, Cade 48, 148
Hayden, Thomas A. 163
Heaton, Brent 29, 72
Heimpel, George 34
Hennemann, Laura 100
Henry, Jerri Lynn 66, 200
Hildebrandt, Julia 17
Hinz, Hariet 36
Hiscox, April 221
Hodgskiss, Connor L. 87, 150
Hoffmann, Clint 127
Hofman, Vernon 213
Hogan, Chris 119
Hooker, Dave 158, 162
Hooker, David C. 2, 180
Ikley, Joe ?, 218
Irmak, Suat 27, 164
Jacobs, Kip E. 18
Jamison, Brendan V. 18
Jennings, Katherine M. 7
Jha, Prashant 67
Jhala, Amit 27, 42, 44, 46, 61, 74, 75, 82, 113, 141, 152, 155, 164, 166, 175, 179, 188
Jiang, Yiwei 135
Johnson, Bill 38
Johnson, William G. ?, 23, 69, 87, 88, 132, 142, 150, 169, 218
Jorgensen, Craig 120
Jorgensen, Niels A. 112, 210, 211
Jugulam, Mithila 13, 130, 193, 203
Kaastra, Allan C. 180
Kappler, Brady 46
Katovich, Elizabeth 35, 36, 206
Kaundun, Deepak 161
Keller, Kyle 184
Klein, Robert N 129
Knezevic, Stevan 19, 25, 27, 55, 56, 57, 58, 59, 60, 61, 62, 80, 155, 164, 166, 168, 188, 223, 225
Knosalla, Lori 206
Kramer, Madison D. 126, 153
Krausz, Ron 68, 83, 86
Kreiner, Julia M. 17
Kristovich, David 221
Kruger, Greg R 10, 11, 14, 51, 64, 90, 91, 92, 97, 98, 99, 101, 102, 103, 104, 122, 124, 125, 127, 139, 174
Kumar, Vipan 54, 67, 155, 159
Laird, Patsy D. 37
Lamb, Alyssa 40
Lambert, Kris N. 8
Lanz, Christa 17
Larue, Clayton 167
Latorre, Debora O. 124
Lawrence, Nevin C. 27, 61, 164, 166, 188

Legleiter, Travis R. 87, 96, 126, 153, 156
Leise, Adam 44
Lerch, Robert N. 65
Lillie, Kathryn 134
Lindquist, John 74, 75, 141
Lins, Ryan 183
Liu, Chun 161
Liu, Lina 108
Liu, Sanzhen 193
Loux, Mark 31, 39, 40, 41, 84, 137
Luck, Brian 95
Lystad, Alexa L. 187
Ma, Rong 18
Magidow, Lillian c. 119, 163
Makepeace, Annie D. 94, 163
Mansfield, Brent C. 53, 135, 145
Marek-Spartz, Kyle 34
Marek-Spartz, Mary 34, 35, 36, 206
Mausbach, Jasmine 42
Mazur, Kelley D. 194
McMullan, Patrick M. 128
Medeiros de Santana, Thalyson 102, 103, 104
Meredith, Ashley 127
Metzger, Brendan A. 162
Meyer, Clint 30, 202, 208
Meyeres, Tyler P. 54
Michael, Jan 157
Miller, Brett 181, 189
Miller, Ryan P. 63, 105, 106, 107, 110
Miller, Sarah 202
Milosevic, Luka G. 59, 60
Mitchell, Paul 113
Mitsdarfer, Charlie 160
Montgomery, Jacob S. 73
Montgomery, Rebecca 206
Moseley, Carroll M. 37
Moses, Adrian J 183
Mueller, Thomas 28
Mueth, Alexander 68
Murphy, Brent P. 70, 137
Nakka, Sridevi 203
Ndayishimiye, Bonheur 10
Nelson, Kelly 3
Nicolai, David 105, 107
Nie, Haozhen 53, 135
Norsworthy, Jason K. 48, 89, 125
Nur Ulusoy, Ayse 25, 168
O'Brien, Sarah R. 18
Obenland, Olivia A. 8
Olson, Bernard 119
Olson, Gene 205
Omielan, Joe 33
Osburn, Andrew W. 31
Oseland, Eric G. 151
Osipitan, O. Adewale 19, 25, 55, 56, 57, 58, 59, 60, 61, 62, 80, 168
Ou, Junjun 13
Ouse, David G. 32
Palecek, David J. 100
Palmer, Eric 161
Pandian, Balaji Aravindhan 193
Parker, Ethan T. 161
Patterson, Eric L. 152, 201
Pauley, John 30, 202, 208
Pavlovic, Pavle 61, 62
Penner, Donald 157
Perez-Jones, Alejandro 154
Perry, Zachary K. 126, 153
Person, Janice 195
Peters, Tom J. 187, 191
Petersen, Wyatt S. 23, 169
Peterson, Dallas E 45, 54, 173
Petrovic, Sofija 97, 98
Pilipovich, Bojana 131
Pinho de Faria, Italo Kaye 21, 22, 170
Polli, Estefania G. 51, 139
Porter, Don 181, 189
Proctor, Christopher 82, 111, 113, 143
Putta, Karthik 203
PV, Vara Prasad 193
Raeder, Alan J. 162
Rahhal, Amin I. 52
Rai, Manoj 30
Rains, Larry J. 81
Ramirez, Samuel N. 76
Rana, Neha 154
Rapp, Ryan E. 154
Rector, Ryan 125
Redmond, Christopher 215

Reeb, Bryan	41
Regalado, Julian	17
Regnier, Emilie	31, 84
Renner, Karen	20, 26, 178
Renz, Mark	109, 112, 210, 211
Renz, Rachel	95
Reynolds, Dan	125, 127
Ribeiro, Victor Hugo V.	49, 50, 95
Rice, Kevin	176
Riechers, Dean E.	8, 18, 160
Rilakovic, Andrea	102, 103
Robinson, Darren	158, 162, 180
Rodrigues, Julia Maria	139
Rodriguez, Oscar	27, 164
Roen, Drew	208
Roozeboom, Kraig	79
Rudnick, Daran	21, 22, 170
Rumler, Allyson M.	72
Rutter, Bader	197
Sadeque, Ahmed	73
Saini, Monika	183, 189
Sarangi, Debalin	131, 152
Sassenrath, Gretchen	79
Sawall, Dustyn	100
Scarparo de Sanctis, Jose H.	155
Schaffer, Steve	114
Schleier, Jerome J.	220
Schramski, John A.	178
Schroeder, Jill	37
Schroeder, Kasey	10, 11, 14, 51, 97, 98, 99, 101, 122, 127, 139
Scott, Allen J.	89
Scott, Dave	219
Scott, Jon E	19, 25, 55, 56, 57, 58, 59, 60, 61, 62, 80, 168
Sherman, Austin D.	133
Shropshire, Christy	1, 165
Shyam, Chandrima	203
Sigler, Cole	30
Sikkema, Peter	17, 125, 158, 162, 165
Sikkema, Peter H.	1, 2, 28, 138, 180
Simpson, David	212
Singh, Maninder	140
Skelton, Joshua	100
Sleugh, Byron	32
Smeda, Reid	24, 66, 81, 89, 172, 192, 200
Smith, Andrea	180
Smith, Daniel	50
Smith, Pam	198
Snodgrass, Eric	217
Soltani, Nader	1, 2, 138, 162, 165
Soni, Neeta	201
Soriano, Rosa	64, 102, 139
Sousa Alves, Guilherme	64, 92, 102, 103, 104, 125, 127, 174
Sparks, Oscar C.	167
Sprague, Christy	4, 20, 43, 47, 116, 125, 178, 186
Stachler, Jeff M.	149
Stahl, Lizabeth	106, 107
Stahlman, Phillip	67, 138, 159
Stepanovic, Strahinja	22
Stephens, Trey	152
Steppig, Nicholas R.	12, 147
Stevenson, Rod	154
Stiles II, Brian	47
Stinchcombe, John R.	17
Stoltenberg, David E.	5, 9, 85, 109
Strachan, Stephen	32
Striegel, Adam	166
Striegel, Sarah	49, 85, 95
Strom, Seth	160
Takano, Hudson K.	9
Tenhumberg, Brigitte	74, 75, 141
Tesso, Tesfaye	193
Thompson, Curtis R	138
Thostenson, Andrew A.	105, 213
Todd, Olivia	201
Todey, Dennis	214
Tonon Rosa, Alexandre	21, 22, 146, 170
Tranel, Patrick	16, 17, 28, 70, 73, 134, 137, 226
Treptow, Don G.	74, 75, 141
Tubbs, William A.	176
Uany de Souza, Thais	99, 101
Ulusoy, Ayse	56
Valdez, Betzy	24, 172
Van Horn, Christopher R.	9
Van Riper, Laura	36, 206
Van Wychen, Lee	37
Varagona, Marguerite J.	167
Velho, Vinicius	104
Villafuerte, Lauren	30

Vukoja, Barbara	11
Waithaka, Bridgit	17
Waldschmidt, Mathew	7
Wang, Junming	221
Warmund, Michele	190
Watteyne, Kevin	42
Wehrbein, Joshua S.	111, 143
Weigel, Detlef	17
Weirich, Jason	66
Werle, Rodrigo	16, 21, 22, 49, 50, 74, 75, 85, 95, 108, 109, 113, 125, 141, 146, 170, 177
Werner, Kaisa M.	131
Westra, Eric	201
Westra, Phil	9, 201
Westrich, Benjamin C.	145
Williams, Linda D.	205
Williams, Marty	222
Willingham, Samuel D.	12, 147
Wilmes, Kaity	82
Wilson, Courtney E.	9
Wright, Stephen I.	17
Wright, Yancy E.	123
Wu, Chenxi	154
Wuerffel, R. Joseph	161
Yerka, Melinda	9, 74, 75, 141
Young, Bryan G.	12, 38, 48, 53, 69, 89, 93, 125, 132, 135, 145, 147, 148
Young, Catlin M.	96
Young, Julie	48, 53, 93
Zaric, Milos	91, 174
Zhang, Chuan-Jie	136
Zimbric, Joseph W.	5, 109
Zimmer, Marcelo	38, 93
Zoerb, Heidi	199

Keyword Index

12-oxophytodienoic acid reductase	8
2,4-D	39, 63, 205
Acetochlor	110, 156
Acetolactate synthase resistance	15
Adjuvants	128
Alfalfa	200
Alfalfa, glyphosate-resistant	63
Alliaria petiolata	206
Alliaria petiolata	34, 36
Amaranthus palmeri	155, 156, 175, 188
Amaranthus rudis	110, 149, 158
Amaranthus tuberculatus	18, 53, 135, 156, 191
Ambrosia trifida	9, 110
Aminocyclopyrachlor	33
Aminopyralid	33, 209
Antagonism	124
Antioxidant enzymes	135
Application timing	83, 179
Atrazine	18
Beta vulgaris	191
Biological control	34, 35, 36, 206
Biotechnology	15
camelina species	136
Ceutorhynchus constrictus	206
Ceutorhynchus scrobicollis	34, 36, 206
Chenopodium album	110
Cirsium arvense	35
cloquintocet-mexyl	8
Cloransulam-methyl	78
Clover	205
Codon deletion	152
Contact Angle	90
Conyza canadensis	38, 39
Corn	3, 24, 110, 111
Cover crop	78, 111
CRISPR	15
Critical Period	155
crop injury	177
Crop Tolerance	193
Crops, minor	191
cross-resistance	152
Cultivation	107, 191
Density	90
Dicamba	63, 83, 149, 156, 175
Drift Control	124
Flumioxazin	83, 149, 156
Fomesafen	53, 63, 78, 110, 135, 149, 156
Forest	34, 36, 206
formulations	157
G210	53
Gene editing	15
genotyping	152
Glufosinate	63, 83, 149, 156
Glycine max	156
Glycine max	3, 28, 63, 78, 83, 107, 110, 111, 149, 172, 177, 179, 200
Glyphosate	9, 63, 83, 149, 191, 209
Glyphosate resistance	9, 156
Glyphosate-resistance	124
Hadroplontus litura	35
Handweeding	107
Herbicide fate	200
Herbicide mode of action	9, 110
Herbicide resistance	9, 15, 18, 53
Herbicide symptomology	135
Imazapic	33, 209
Imazapyr	209
Imazethapyr	110
Integrated weed management	78
Invasive species	209
Lactofen	53
Lepidium barnebyanum	36
Mechanical weed control	191
Medicago sativa	63
Medicago sativa	63
Mesotrione	18, 110, 193
Metribuzin	83, 177
Metsulfuron	33
Mowing	33
multiple-herbicide resistance	152
Nasturtium gambelii	36
No-tillage	39
Nozzle Selection	124
Optimal Droplet Size	90, 124
Organic agriculture	24, 172
Pastures	35
Phaseolus vulgaris	188
Plant growth regulators	33
Prairies	35
protoporphyrinogen oxidase inhibiting herbicides	53, 135
Public lands	35

Reactive oxygen species	135
Resistance management	158
Roadsides	35
RT-qPCR	8
Rye	111
Safety	38
Saflufenacil	110
Secale cereale	111
site of action	152
Solanum physalifolium	188
Solidago canadensis	83
Sorghum	193
Soybean	3, 39, 53, 63, 78, 110, 111, 149, 155, 156, 172, 175, 177, 179
soybean row spacing	175
Soybean, glyphosate-resistant	38
Sulfentrazone	177
Surface Tension	90
survey	107
Tamarix ramosissima	209
Taraxacum officinale	63
tomato	157
Transcriptome	205
Triclopyr	209
Trifolium spp.	205
Triticum aestivum	83
Triticum aestivum	8, 83
Viscosity	90
volatility	157
Weed biology	34
Weed density	111
Weed management	24, 63, 107, 149, 172, 191
Weed suppression	111
Yield loss	191
Zea mays	3, 24, 107, 110, 111, 158

Bruce Ackley
2761 Shrewsbury Rd
Columbus, OH 43221

Tim Adcock
219 Redfield Dr.
Jackson, TN 38305

Renee Adler
2515 123rd Ave
Wapello, IA 52653

Scott Akin
5426 State Route 121 NORTH
Murray, KY 42071

Craig Alford
8305 NW 62nd Ave, PO Box 7060
Johnston, IA 50131

Jill Alms
235 Ag Hall Box 2207A
Brookings, SD 57007

Jared Alsdorf
7275 N US 421
Sheridan, IN 46069

Aman Anand
1290 FIFIELD PLACE
FALCON HEIGHTS, MN 55108

Lucas Araujo
1405 Veterans dr. #414
Lexington, KY 40456

Gregory Armel
26 Davis Drive, P.O. Box 13528
Research Triangle Park, NC 27709

Nikola Arsenijevic
1575 Linden Drive
Madison, WI 53706

Chad Asmus
3316 Sugar House Street
Raleigh, NC 27614

Austin Baker
2842 S 825W
Lapel, IN 46051

Rebecca Baker
3501 Agronomy Hall
Ames, IA 50014

Anna Baldwin
200 Old Factory Rd
Sharon, WI 53585

Scott Bales
1066 Bogue street
East Lansing , Mi 48824

Ethann Barnes
534 Lakeside Dr
Lincoln, NE 68528

Isaac Barnhart
1712 Claflin Road
Manhattan, KS 66503

Arthur Bass
1596 NE 58th Ave
Des Moines, IA 50313

David Bauer
1810 North Hornet Ave.
Clovis, CA 93619

Roger Becker
411 Borlaug Hall 1991 Upper Buford Cir
St Paul, MN 55108

Lisa Behnken
863 30th Ave SE
Rochester, MN 55904

Clint Beiermann
4502 Ave I
Scottsbluff, Ne 69361

Susan Bellman
N6084 Johnson Rd
Delavan, WI 53115

Austin Bennett
1109 Ivy Ave
Richland, IA 52585

Lauren Benoit
20 Main St. E.
Ridgetown Ontario N0P 2C0
Canada

Mark Bernards
Knoblauch Hall 145
Macomb, IL 61455

Brad Bernhard
322A ERML, 1201 W. Gregory Drive
Urbana, IL 61801

Pete Berry
109 Crop Science Building, 3050 SW Campus Way
Corvallis, OR 97331

Shaun Billman
110 Waters Hall
Columbia, MO 65211

Steven Bowe
PO Box 13528
RTP, NC 27709

Dane Bowers
P.O. Box 18300
Greensboro, NC 27409

Kevin Bradley
201 Waters Hall
COLUMBIA, MO 65211

Aaron Brooker
1066 Bogue Street
East Lansing, MI 48823

Josh Brosz
200 Old Factory Road
Sharon, WI 53585

Joe Bruce
562 S Prairie St
Cary, IL 60013

Bob Bruss
4020 Aerial Center Parkway, Suite 101
Morrisville, NC 27560

Gatlin Bunton
5 Waters hall
Columbia, MO 65211

Erin Burns
1066 Bogue Street
East Lansing, MI 48824

Tommy Butts
15351 Highway 5, APT 224
Cabot, AR 72023

Dakota Came
2004 Throckmorton Plant Sciences Center
Manhattan, KS 66502

Colton Carmody
1205 Lincoln Dr, MC 4415
Carbondale, IL 62901

Paula Carneiro
1405 Veterans Drive
Lexington, KY 40546

Tate Castillo
112 Parkview St
Alma, KS 66401

Isidor Ceperkovic
402 W. State Farm Rd.
North Platte, NE 69101

Parminder Chahal
279 Plant Science Hall, East campus
University of Nebraska-Lincoln
Lincoln, NE 68583

Sushila Chaudhari
Department of Crop and Soil Science
Raleigh, NC 27695

Luke Chism
2004 Throckmorton PSC 1712 Claflin Road
Manhattan, Ks 66506

Mike Christoffers
Dept 7670, PO Box 6050
Fargo, ND 58108

Allan Ciha
3032 Shadyside Drive
Stoughton, WI 53589

Carl Coburn
76268 NE-47
Gothenburg, Ne 69138

Brady Code
28 Fall Harvest Dr
Kitchener Ontario N2P 2M2
Canada

Ryan Collins
lexington
lexington, KY 40506

Adam Constine
1066 Bogue St
East Lansing, MI 48824

David Cornett
200 Mero St, 3rd Floor East
Frankfort, KY 40622

Max Coura Oliveira
1575 Linden Drive
Madison, WI 53706

Todd Cowan
70257 Airport Line, R.R. #1
Exeter Ontario N0M 1S4
Canada

John Craft
4450 Beaumont Rd.
Lansing, MI 48910

Scott E. Cully
17256 New Dennison Rd
Marion, IL 62959

Randall Currie
4500 E Mary St
Garden City, KS 67846

Ivan Cuvaca
2004 Throckmorton Plant Sci Ctr, 1712 Claflin Road
Manhattan, KS 66506

Gregory Dahl
3336 Casey Street
River Falls, WI 54022

Vince Davis
707 Ariel Lane
Verona, WI 53593

Jose Henrique De Sanctis
279 Plant Science Hall
Lincoln, Ne 68583

Madison Decker
1231 Lincoln Dr
Carbondale , IL 62901

Tomas Delucchi
915 West State st. Botany Department - Lilly 1446
West Lafayette, IN 47906

Stephanie DeSimini
915 W State St.
West Lafayette, IN 47907

Ryan DeWerff
1575 Linden Dr
MADISON, WI 53705

Anita Dille
1022 Throckmorton Hall
Manhattan, KS 66506

Sarah Dintelmann
1205 Lincoln Dr, MC 4415
Carbondale, IL 62901

Brian Dintelmann
5 Waters Hall
Columbia , MO 65211

Sarah Dixon
108 Waters Hall
Columbia, MO 65211

Anthony F Dobbels
223 Kottman Hall, 2021 Coffey Rd.
Columbus, OH 43210

Nathaniel Drewitz
PO Box 650 531 Dewey St
Foley, MN 56329

Dirk Drost
PO Box 18300
Greensboro, NC 27419

Stu Duncan
NE Area Extension Office, 1007 Throckmorton Hall
Manhattan, KS 66506

Cheryl Dunne
7145 58th Ave
Vero Beach, FL 32967

Greg Elmore
800 North Lindbergh Blvd., E1SB,
St. Louis, MO 63167

Cody Evans
2435 clayton rd
franklin, IL 62638

Keith Evans
6031 Fleetwood Drive
Lincoln, NE 68516

Matt Faletti
214 S. Gore Ave
St. Louis, MO 63119

Rodger Farr
402 W. State Farm Rd.
North Platte, NE 69101

Shea Farrell
203 Waters Hall
Columbia , MO 65211

Walt Fick
Agronomy Dept. TH
Manhattan, KS 66506

Justine Fisher
1066 Bogue Street
East Lansing, MI 48824

Helen Flanigan
1477 S Franklin Rd
Greenwood, IN 46143

Nick Fleitz
375 Fifth Ave NW
New Brighton , MN 55112

Darlene Florence
625 E. Catabwa Ave
Mt. Holly, NC 28120

Aaron Franssen
1526 Bluff Road
Pleasant Dale, NE 68423

John Frihauf
2401 Pester Ridge Road
Lincoln, NE 68523

Karla Gage
1205 Lincoln Drive MC 4415
Carbondale, IL 62901

Darci Giacomini
1201 W. Gregory Drive
Urbana, IL 61801

Jim Gill
12156 Falk Tr.
Northfield, MN 55057

Jeffrey Golus
402 West State Farm Road
North Platte, NE 69101

Luiz Goncalves
Av Roraima 1000
Santa Maria Rio, Grande do Sul
Brazil 97105900

Lisa Gonzini
N-333 Turner, 1102 S Goodwin
Urbana, IL 61801

Jared Goplen
475 90th St. SW
Benson, MN 56215

Greg Grant
8124 Strecker Ln
Plano, TX 75025

Cody Gray
11417 Cranston Drive
Peyton, CO 80831

J D Green
413 Plant Sci Bldg
Lexington, KY 40546

Dean Grossnickle
107 School St
Gilbert, IA 50105

Garrison J. Gundy
1035 County Rd 300 E
Seymour, IL 61875

Travis Gustafson
1728 Idlewood Ln
Grand Island, NE 68803

Adam Guy
1109 Ivy Ave
Richland, IA 52585

Jesse Haarmann
915 W State St.
West Lafayette, , IN 47907

Aaron Hager
1102 S Goodwin N-321 Turner Hall
Urbana, IL 61801

Brett Hall
7275 N US 421
Sheridan, IN 46069

Ryan Hamberg
330th st
slater, IA 50244

Devin Hammer
5926 E US Highway 14
Janesville, WI 53546

Erin Haramoto
411 Plant Sciences Building
Lexington, KY 40506

Nick Harre
915 W. State St.
West Lafayette, IN 47909

Bob Hartzler
1126C Agronomy Hall
Ames, IA 50011

Linda Harvey
1201 S Dorner Dr.
Urbana, IL 61801

Harlene Hatterman-Valenti
PO Box 6050 Dept 7670
Fargo, ND 58108

Nathan Haugrud
474G Loftsgard Hall PO Box 6050
Fargo, ND 58102

Amy Hauver
269 Plant Science
Lincoln, Ne 68503

Marshall Hay
2004 Throckmorton Plant Sciences Center
Manhattan, KS 66506

Thomas Hayden
4033 Kensington Place
Owensboro, KY 42301

Cade Hayden
915 West State Street
West Lafayette, IN 47907

Brent Heaton
18310 North 350th Road
Industry, IL 61440

Byron Hendrix
3200 Southwest Freeway, Suite 1200
Houston, TX 77027

Joey Heneghan
4204 Bannon Road
Marshall, WI 53559

Shane Hennigh
303 Briarwood Ln
Hillsboro, KS 67063

Jerri Lynn Henry
200A Waters Hall
Columbia, MO 65211

David Hillger
5934 N 450 W
Thorntown, IN 46071

John Hinz
54311 - 115th St
Story City, IA 50248

Connor Hodgskiss
915 W. State Street
West Lafayette, IN 47907

Stott Howard
416 Foster Dr
Des Moines, IA 50312

Joe Ikley
915 W State Street
West Lafayette, IN 47907

Trevor Israel
1601 E Dana Dr
Sioux Falls, SD 57105

Kip Jacobs
1102 S Goodwin Ave
Urbana, IL 61801

Kevin Jarek
3365 W. Brewster St
Appleton, WI 54914

Amit Jhala
Plant Science Hall, East Campus of the UNL
Lincoln, NE 68583

Dave Johnson
701 56th St.
Des Moines, IA 50312

Paul Johnson
Box 2207a Berg Hall
Brookings, SD 57007

Niels Jorgensen
1575 Linden Drive
Madison, WI 53706

Mithila Jugulam
2004 Throckmorton Hall
Manhattan, KS 66502

Bob Kacvinsky
2915 Tennyson Street
Lincoln, Ne 68516

Brady Kappler
20201 North Stable Dr
Eagle, NE 68347

Ron Kayea
315 Cherry Lane
New Castle, DE 19720

Angela J. Kazmierczak
7620 Memory Lane
Horace, ND 58047

Clair Keene
14120 Highway 2
Williston, ND 58801

Jim Kells
286 Plant & Soil Sci Bldg
E Lansing, MI 48824

Corey Klaphake
210A East Tomaras Ave
Savoy, IL 61874

Robert Klein
402 W State Farm Rd
North Platte, NE 69101

Troy Klingaman
407 Denton Drive
Savoy, IL 61874

Delbert Knerr
4962 South Rangeline Road
Columbia, MO 65201

Dr. Stevan Knezevic
57905 866 Rd
Concord, Ne 68728

Jon kohrt
1028 90th st
west des moines, IA 50266

Madison Kramer
3196 E 700 S
Lyn, IN 47355

Greg Kruger
402 W State Farm Rd
North Platte, NE 69101

Vipan Kumar
1232 240th Ave
Hays, KS 67601

Alyssa Lamb
2021 Coffey Road
Columbus, OH 43210

Nicole Langdon
8621 Sideroad 15 RR2
Arthur Ontario N0G 1A0
Canada

Jeff Laufenberg
83 Easterlies Court
Fond du lac, WI 54937

James Lee
Iowa State University 2104 Agronomy Hall
Ames, IA 50011

Mike Leetch
25742 338th lane
Adel, IA 50003

Travis Legleiter
1205 Hopkinsville Street
Princeton, KY 42445

Adam Leise
279 Plant science hall
lincoln, Ne 68583

Kathryn Lillie
1201 W Gregory Dr
Urbana, IL 61801

Ryan Lins
2000 Co Rd 121 NE
Rochester , MN 55906

Jami Loecker
6045 Flintstone Cir
Manhattan, KS 66503

Dennis Long
PO Box 155
Manchester, TN 37349

Fernando Lopez
504 Carnegie Center
Princeton, NJ 8540

Mark Loux
2021 Coffey Rd
Columbus, OH 43221

Gabrielle de Castro Macedo
402 State Farm Road
North Platte, NE 69101

Iththiphonh Macvilay
2104 Agronomy Hall 716 Farmhouse Lane
Ames, IA 50011

Brent Mansfield
915 W State St
West Lafayette, IN 47907

Jasmine Mausbach
279 Plant Science Hall
Lincoln, NE 68583

Doug Maxwell
1102 S Goodwin Ave., N-333 Turner Hall
Urbana, IL 61801

Chris Mayo
625 Plum Creek Circle
Gardner, KS 66030

Patrick McMullan
604 NW 8th St
Grimes, IA 50111

Marc McPherson
7801 Whitepine rd
Richmond, VA 23237

Ingo Meiners
26 Davis Drive
RTP, NC 27709

Brendan Metzger
120 Main St. East
Ridgetown Ontario N0P 2C0
Canada

Clint Meyer
701 North C Street
Indianola, IA 50125

Tyler Meyeres
2004 Throckmorton Plant Sciences Center, 1712 Claflin Rd
Manahttan, KS 66506

Eric Miller
1205 Lincoln Drive
Carbondale, IL 62901

Brett Miller
3545 42nd Ave S
Fargo, ND 58104

Ryan Miller
863 30th ave SE
Rochester, MN 55904

Charlie Mitsdarfer
N-333 Turner Hall, 1102 S. Goodwin Ave
Urbana, IL 61801

Jake Montgomery
1201 W Gregory Dr
Urbana, IL 61801

Jesaelen Moraes
402 West State Farm Rd
North Platte, NE 69101

Carroll Moseley
410 Swing Road
Greensboro, NC 27265

Alexander Mueth Mueth
1205 Lincoln Drive MC 4415
Carbondale, IL 62901

Brent Murphy
1201 W Gregory Dr
Urbana, IL 61801

Barry Nash
2737 W 7th St
Ramsey, IL 62080

Terry Nash
7664 Smythe Farm Rd
Memphis, TN 38120

Matt Nelson
53751 650th St
Atlantic, IA 50022

Brent Neuberger
3508 Ashworth Rd
W Des Moines, IA 50265

Glenn Nice
1575 Linden Dr
Madison, WI 53706

Dave Nicolai
4100 220th Street West
Farmington, MN 55024

Ayse Nur Ulusoy
57905 866 RD
Concord, NE 68728

Olivia Obenland
1102 S. Goodwin Ave., N335
Urbana, IL 61801

Joe Omielan
Plant & Soil Sci, Rm 417, 1405 Veterans Dr.
Lexington, KY 40546

Andrew Osburn
300 Kottman Hall
Columbus, OH 43210

Eric Oseland
5 Waters Hall
Columbia, IL 65211

Adewale Osipitan
57905 866 RD
Concord, NE 68728

David Palecek
3336 Casey Street
River Falls, WI 54022

Troy Palmer
504 Carnegie center
Princeton, NJ 8540

Balaji Aravindhan Pandian
Department of Agronomy, Throckmorton Plant Sciences Centre
Manhattan, KS 66502

Crystal Parker
504 Carnegie Center
Princeton, NJ 8543

John Pauley
701 North C Street
Indianola, IA 50125

Matthew Pauli
840 Settler Trail
Sheboygan Falls, WI 53085

John Andrew Pawlak
14571 Arcadia Woods DR Spring
Spring Lake, MI 49456

Scott Payne
2369 330th St.
Slater, IA 50244

Stephen Pearson
PO Box 7900
Wheaton, IL 60187

Donald Penner
1066 Bogue St
E Lansing, MI 48824

Zach Perry
1405 Veterans Drive
Lexington , KY 40546

Tom Peters
474G Loftsgard Hall, NDSU Dept 7670
Fargo, ND 58108

Brent Petersen
4981 2nd Street SE
St. Cloud, MN 56304

Wyatt Petersen
3131 Brunswick Ct. S
Lafayette, IN 47909

Dallas E Peterson
113 Harvard Place
Manhattan, KS 66503

Mark Peterson
5632 Acre Lane
West Lafayette, IN 47906

Italo Pinho de Faria
402 West State Farm Road
North Platte, NE 69101

Justin Pollard
10864 SW Reno Dr
Lathrop, MO 64465

Gary Powell
1066 Bogue St
East Lansing, MI 48824

David Powell
6941 Drew Dr
Edwardsville, IL 62025

Michael Probst
320 County Road 1100 N
Seymour, IL 61875

Richard Proost
445 Henry Hall
Madison, WI 53706

Jessica Quinn
120 Main St East
Ridgetown Ontario N0P 2C0
Canada

Joe Rains
343 NW 1351st , Box 13
Holden, MO 64040

Larry Rains
823 Colorado St.
Manhattan , KS 66502

Samuel Ramirez
1205 Lincoln Drive MC 4415
Carbondale, IL 62901

Neha Rana
800 N Lindbergh Blvd
St Louis , MO 63167

Ryan Rapp
40660 252nd St
Mitchell, SD 57301

Duane Rathmann
604 9th St NE
Waseca, MN 56093

Ryan Rector
800 N Lindbergh Blvd
Creve Coeur, MO 63167

Bryan Reeb
223 Kottman Hall, 2021 Coffey Rd.
Columbus, OH 43210

Dawn Refsell
220 NE Brown Rd
Lathrop, MO 64465

Jim Reiss
1429 S. Shields Drive
Waukegan, IL 60085

Karen Renner
A285 Plant & Soil Sci Bldg
E Lansing, MI 48824

Mark Renz
1575 Linden Dr
Madison, WI 53706

Victor Ribeiro
Linden Drive
Madison, WI 53706

Eric Riley
800. N. Lindbergh Blvd.
St. Louis, MO 63167

Lanae Ringler
815 2nd St. NW
New Prague, MN 56071

Jon Rollins
2842 S 825W
Lapel , IN 46051

Kristin Rosenbaum
24007 E St Hwy H
Coffey, MO 64636

Jared Roskamp
486 N Co Rd 1000 E
Sutter, IL 62373

Claudio Rubione
16483 County Seat Hwy
Georgetown, de 19947

Larissa Ruchotzke
3336 Casey St
River Falls, WI 54022

Bradley Ruden
105 392nd Ave S
Aberdeen, SD 57401

Allyson Rumler
1 University Circle
Macomb, IL 61455

Seshadri Sajjala
11055 Wayzata Blvd
Minnetonka, MN 55305

joseph sandbrink
1219 McKinley Avenue
St. Louis, MO 63119

Lowell Sandell
110 Eagle View Dr.
Ashland, NE 68003

Debalin Sarangi
370 Olsen Blvd.
College Station, TX 77843

Bill Schaumberg
4412 EAGLE LANDING CT
DE PERE, WI 54115

Irvin Schleufer
Box 66
Clay Center, NE 68933

Gary Schmitz
537 County Road 2550 N
Mahomet, IL 61853

Brandon Schrage
115 Mitchell Street.
Bradshaw, NE 68319

John Schramski
1066 Bogue St.
East Lansing, MI 48824

Eric Schultz
8563 S 102nd Street
La Vista, Ne 68128

brady schulzetenberg
1761 2ND ST SE
GOODRICH, ND 58444

Kara Schut
8106 Ingalls Rd
Belding, MI 48809

Jon Scott
57905 866 Rd
Concord, NE 68728

Allen Scott
108 Waters Hall
Columbia, MO 65211

Carmine Sesa
2 Anglers Pond Court
HILTON HEAD, SC 29926

Frank Sexton
200 Old Factory Rd
Sharon, WI 53585

Austin Sherman
413 Plant Sciences Building
Lexington, KY 40546

Chandrima Shyam
2004 Throckmorton PSC
Manhattan, KS 66506

Peter H Sikkema
120 Main Street East
Ridgetown Ontario N0P 2C0
Canada

David Simpson
9747 Greenthread Dr
Zionsville, IN 46077

Alec Simpson
315 Cherry Lane
New Castle, DE 19720

Dr. Reid Smeda
110 Waters Hall
Columbia, MO 65211

Dan Smith
445 Henry Mall Rm 318
Madison, WI 53706

Pamela Smith
2530 S. Forest Crest Road
Decatur, IL 62521

Andrea Smith
120 Main St East
Ridgetown Ontario N0P 2C0
Canada

Nader Soltani
120 Main St. East
Ridgetown Ontario N0P 2C0
Canada

Eric Spandl
1080 County Road F West
Shoreview, MN 55126

Christy Sprague
1066 Bogue St.
E Lansing, MI 48824

Lizabeth Stahl
1527 Prairie Drive
Worthington, MN 56187

Greg Steckel
321 210th Avenue
Monmouth, IL 61462

Nicholas Steppig
915 W State St
West Lafayette, IN 47907

David Stevenson
2024 Shelby 210
Clarence, MO 63437

Brian Stiles II
1066 Bogue St
East Lansing, MI 48824

Rhett Stolte
1701 Towanda Ave
Bloomington, IL 61701

David E Stoltenberg
1575 Linden Dr
Madison, WI 53706

Adam Striegel
279E Plant Science Hall PO Box 830933
Lincoln , NE 68583

Seth Strom
N-335 Turner Hall, 1102 S. Goodwin
Urbana, IL 61801

Dennis Sullivan
742 NE 8th St
Ankeny, IA 50021

Susan Sun
315 Cherry Lane
New Castle, DE 19720

Brent Sunderlage
1205 Lincoln Dr.
Carbondale, IL 62901

Scott Swanson
5040 E. Brooke Ct.
Byron, IL 61010

Matt Terry
605 California Ave
Sunnyvale, CA 94085

David Thomas
608 Kratz Road
Monticello, IL 61856

Kevin Thorsness
21 Prairiewood Dr
Fargo, ND 58103

Chad Threewits
2191 W 900 N-90
Markle, IN 46770

Dennis Todey
1015 N. University Blvd.
Ames, IA 50011

Alexandre Tonon Rosa
3835 Baldwin Avenue Apt. 69
Lincoln, NE 68504

Patrick Tranel
1201 W Gregory Dr, 360 ERML
Urbana, IL 61801

Don Treptow
1870 N 37th, 105D KCR
Lincoln, NE 68583

Tim Trower
E10249A Hoot Owl Valley Rd
Baraboo, WI 53913

Zachary Trower
2789 Hwy 22
Riverside, IA 52327

William Tubbs
5 Waters Hall
Columbia, MO 65211

Darren Unland
26 Davis Drive
Research Triangle Park, NC 27709

Gordon Vail
PO Box 18300
Greensboro, NC 27419

Betzy Valdez
205 Waters Hall
Columbia, MO 65211

Stephen Valenti
5132 Rosecreek Pkwy
Fargo, ND 58104

David Vos
235 Berg Ag Hall - SDSU
Brookings, SD 57006

Daniel Waldstein
26 Davis Drive, P.O. Box 13528
Research Triangle Park, NC 27709

Cristin Weber
12101 Thorps Rd.
Clinton, IL 61727

Mike Weber
2208 N 9th St
Indianola, IA 50125

Gerald Weed
7276 Country Club Lane
West Chester, OH 45069

Josh Wehrbein
1825 N. 38 St.
Lincoln, NE 68503

Gery Welker
2292 S 400 W
Winamac, IN 46996

Rodrigo Werle
1575 Linden Drive
Madison, WI 53706

Ben Westrich
2427 Fleming Drive
West Lafayette, IN 47906

Derek Whalen
320 County Road 1100 North
Seymour, IL 61875

Daniel Wilkinson
1248 W Pratt Rd
DeWitt, MI 48820

Marty Williams
1102 S Goodwin
Urbana, IL 61801

Sam Willingham
26 Davis Drive
Research Triangle Park, NC 27709

Kaity Wilms
1400 R Street
Lincoln, NE 68588

Carla Yerkes
9330 Zionsville Rd.
Indianapolis, IN 46268

Bryan Young
915 W. State St., Botany and Plant Pathology
West Lafayette, IN 47907

Catlin Young
1480 Claxton Road
Dawson Springs, KY 42408

Milos Zaric
402 West State Farm Road
North Platte, NE 69101

Joseph Zimbric
1575 Linden Dr.
Madison, WI 53706

Marcelo Zimmer
915 West State St. Department of Botany
West Lafayette, IN 47907