Proceedings of the 71th Annual Meeting of the North Central Weed Science Society

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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 lisitng. These proceedings were published on 12/23/2016.

PROGRAM

2016 Officers/Executive Committee

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General Session

Welcome to Iowa. Bill Northey*; Iowa Department of Agriculture and Land Stewardship, Des Moines, IA (100)

Bridging to Better Times. Dermot J. Hayes*; Iowa State University, Ames, IA (101)

Washington DC Report. Lee Van Wychen*; National and Regional Weed Science Societies, Alexandria, VA (102)

NCWSS Presidential Address. Anita Dille*; Kansas State University, Manhattan, KS (103)

Remembering Former NCWSS Members and Friends. Aaron G. Hager*; University of Illinois, Urbana, IL (104)

Announcements. Gregory K. Dahl*; Winfield United, River Fs, WI (105)

POSTER SECTION

***PRESENTER † STUDENT POSTER CONTEST PARTICIPANT**

Agronomic Crops I (Corn, Sorghum, Cereals)

†Preemergence Activity of Chloroacetamide Herbicides on a Multiple Herbicide-Resistant Population of Waterhemp (*Amaranthus tuberculatus*). Seth A. Strom*, Aaron G. Hager, Dean Riechers; University of Illinois, Urbana, IL (1)

Evaluation of Post-emergence Herbicides for Managing Horseweed (*Conyza canadensis*) in Corn. Chris Proctor*, Amit Jhala; University of Nebraska Lincoln, Lincoln, NE (2)

†Effects of Clethodim and Dicamba Tank-mixtures on Control of Volunteer Corn (*Zea mays*) and Grain Sorghum (*Sorghum bicolor*). Isidor Ceperkovic*, Andrea Rilakovic, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (3)

†Grain Sorghum Response to Huskie™ following Treatment with Herbicide Mixtures Containing Mesotrione. Seth Menzer*, Mithila Jugulam, Curtis R. Thompson; Kansas State University, Manhattan, KS (4)

Critical Period of Grass Weed Control in ALS-Resistant Sorghum. Jeffrey J. Albers*[1], Anita Dille[1], Curtis R. Thompson[1], Phillip W. Stahlman[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Research and Extension, Hays, KS (5)

Biochemical Analysis and Transcript Profiling of Etiolated Sorghum Coleoptiles Following Safener or Oxylipin Treatment. Rong Ma*[1], Patrick J. Brown[2], Kris N. Lambert[2], Anatoli V. Lygin[2], Mayandi Sivaguru[2], Stephen P. Moose[2], Dean E. Riechers[2]; [1]UIUC, Urbana, IL, [2]University of Illinois, Urbana, IL (6)

†Weed Control in Spring Malting Barley. Alyssa Lamb*[1], Mark M. Loux[1], Tony Dobbels[2]; [1]The Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH (7)

Weed Control in Field Pennycress. Logan H. Bishop*[1], Dr. Kelly Nelson[2]; [1]Universtiy of Missouri - Columbia, Columbia, MO, [2]University of Missouri - Columbia, Columbia, MO (8)

†Preharvest Herbicide Effects on Winter Wheat. Kelsey M. Rogers*[1], Christy L. Sprague[2]; [1]Michigan State University, Lansing, MI, [2]Michigan State University, East Lansing, MI (9)

†Efficacy of Variable Rate Soil-applied Herbicides Based on Soil Electrical Conductivity and Organic Matter Differences. Garrison J. Gundy*, Anita Dille, Antonio R. Asebedo; Kansas State University, Manhattan, KS (10)

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

†Integration of Residual Herbicides and Cover Crops for Weed Control in a Soybean Production System. Derek M. Whalen*[1], Mandy D. Bish[2], Meghan Biggs[1], Eric Oseland[1], Zach Trower[1], Blake R. Barlow[1], Shea Farrell[1], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (12)

DuPont Herbicide Programs for Conventional-Till Dicamba-Tolerant Soybeans. Keith A. Diedrick*[1], Kelly A. Backscheider[2], Eric Castner[3], Richard Edmund[4], Kevin L. Hahn[5], Robert Rupp[6], Dan Smith[7], Charles E. Snipes[8], Bruce V. Steward[9], Robert Williams[10], Victoria A. Kleczewski[11], Jeffery T. Krumm[12], Michael D. Meyer[13], Scott E. Swanson[14], Larry H. Hageman[14], Keith D. Johnson[15], Marsha J. Martin[16]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont Crop Protection, Shelbyville, IN, [3]DuPont Crop Protection, Weatherford, TX, [4]DuPont Crop Protection, Little Rock, AR, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Edmund, OK, [7]DuPont Crop Protection, Madison, MS, [8]DuPont Crop Protection, Greenville, MS, [9]DuPont Crop Protection, Overland Park, KS, [10]DuPont Crop Protection, Raleigh, NC, [11]DuPont Crop Protection, Middletown, DE, [12]DuPont Crop Protection, Hastings, NE, [13]DuPont Crop Protection, Johnston, IA, [14]DuPont Crop Protection, Rochelle, IL, [15]DuPont Crop Protection, Grand Forks, ND, [16]DuPont Crop Protection, Columbus, OH (13)

†Evaluations of DuPont™ Basis Blend® Preemergence Herbicide Alone and in Tank-mix Combinations for use in BOLT™ Technology Soybeans. Nickolas D. Theisen*[1], Larry H. Hageman[2], Scott E. Swanson[2], Kelly A. Backscheider[3], Keith A. Deidrick[4], Kevin L. Hahn[5], David H. Johnson[6], Michael D. Meyer[6], Victoria A. Kleczewski[7], Jeffery T. Krumm[8], Marsha J. Martin[9], Bruce V. Steward[10]; [1]University of Wisconsin- Platteville, Platteville, WI, [2]DuPont Crop Protection, Rochelle, IL, [3]DuPont Crop Protection, Shelbyville, IN, [4]DuPont Crop Protection, DeForest, WI, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Johnston, IA, [7]DuPont Crop Protection, Middletown, DE, [8]DuPont Crop Protection, Hastings, NE, [9]DuPont Crop Protection, Columbus, OH, [10]DuPont Crop Protection, Overland Park, KS (14)

†Critical Time for Weed Removal in Soybeans is Influenced by Soil Applied Herbicides. Maxwel C. Oliveira*, Jon E. Scott, Stevan Knezevic; University of Nebraska-Lincoln, Concord, NE (15)

Tank Mix Partners with Paraquat for Enhanced Grass Control. Marsh M. Hay*, Das E. Peterson; Kansas State University, Manhattan, KS (16)

†Comparison of Weed Management Systems in Six Soybean Technologies. Matthew C. Geiger*[1], Karla L. Gage[2], Ronald F. Krausz[3]; [1]Southern IL University, Carbondale, IL, [2]Southern Illinois University, Carbondale, IL, [3]Southern Illinois University, Belleville, IL (17)

†Effect of soil applied protoporphyrinogen oxidase inhibitor herbicides on soybean seedling disease severity. Nicholas J. Arneson*[1], Loren J. Giesler[1], Rodrigo Werle[2]; [1]University of Nebraska, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (18)

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Soybean Injury from Dicamba and 2,4-D Tank Contamination. Nader Soltani*[1], Robert E. Nurse[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Agriculture Canada, Harrow, ON (20)

The Influence of Carrier Water Hardness on 2,4-D Choline Efficacy. Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (21)

Enlist Soybean Weed Control Options for Controlling 5 Way Resistant Waterhemp Population in Illinois. David M. Simpson*[1], Kevin D. Johnson[2]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Danville, IL (22)

†Emergence Pattern of Palmer Amaranth in Response to Different Rates of Metribuzin and Sulfentrazone. Matheus de Avellar*, Liberty Butts, Greg R. Kruger, Rodrigo Werle; University of Nebraska-Lincoln, North Platte, NE (23)

†Effect of Soil Herbicides on a PPO-sensitive Soybean under Weed-free Conditions. Rhett L. Stolte*[1], Ronald F. Krausz[2], Karla L. Gage[1]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (25)

Managing Waterhemp in Soybeans with Layered Residual Herbicides. A Strategy for Controlling Herbicide Resistant Waterhemp in Minnesota. Lisa M. Behnken*[1], Fritz R. Breitenbach[2], Jeffrey L. Gunsolus[3], Phyllis M. Bongard[3]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota Extension, St. Paul, MN (26)

†Palmer Amaranth Control in Double Crop Dicamba-Glyphosate-Resistant Soybeans. Nathaniel R. Thompson*[1], Das E. Peterson[1], Gary L. Cramer[2], Chris M. Mayo[3], Cathy L. Minihan[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hutchinson, KS, [3]Monsanto, Gardner, KS (27)

†Rainf Impacts the Residual Activity of Dicamba on Morningglory (*Ipomoea spp.)* and Common Waterhemp *(Amaranthus rudis)*. Andy J. Luke*, Reid Smeda; University of Missouri, Columbia, MO (28)

Roundup Ready 2 Xtend Soybean Systems. Scott A. Nolte*; Monsanto, St. Louis, MO (29)

Roundup Ready[R] Xtend Crop System: Stewardship in Practice. Sara M. en*[1], Susan E. Curvey[2], Michelle R. Starke[2], Boyd J. Carey[2]; [1]Monsanto, Bonnie, IL, [2]Monsanto, St. Louis, MO (30)

†Timing of Herbicide Applications and/or Tillage Affects Control of Glyphosate-resistant Horseweed in Soybean. Parminder S. Chahal*[1], Amit Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska Lincoln, Lincoln, NE (31)

Scheduled Herbicide Applications and Micro-rates: Is There a Fit in Herbicide-resistant Soybean? Mark L. Bernards*, Brent S. Heaton; Western Illinois University, Macomb, IL (32)

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†Efficacy of Halauxifen-methyl Herbicide Programs for Management of Glyphosate-resistant Horseweed (*Conyza canadensis* L.) in Soybean. Marcelo Zimmer*[1], Bryan Young[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (34)

Waterhemp Control in Edible Lima Bean Production in SE Minnesota. Fritz R. Breitenbach*[1], Lisa M. Behnken[2]; [1]University of Minnesota Extension, Rochester, MN, [2]University of Minnesota, Rochester, MN (35)

†Examining Commercial Seed Mixtures for the Presence of Weed Species. Eric G. Oseland*, Meghan Biggs, Mandy Bish, Kevin W. Bradley; University of Missouri, Columbia, MO (36)

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†Influence of Nozzle Spacing, Boom Height and Nozzle Type on the Efficacy of Glufosinate, Dicamba, Glyphosate and Saflufenacil. Lucas Giorgianni Campos*, Kasey Schroeder, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (38)

†Influence of Spray Volume and Droplet Size on the Control of Palmer Amaranth (*Amaranthus palmeri*) and Horseweed (*Conyza canadensis*). Henrique Campos*, Bruno Canella Vieira, Thomas R. Butts, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (39)

Influence of Strikelock on Herbicide Performance. Laura Hennemann*; Winfield United, River Fs, WI (40)

†Influence of Nozzle Type and Pressure on Droplet Size from Roundup PowerMax, Clarity, and Roundup PowerMax and Clarity Tank-mixtures. André de Oliveira Rodrigues*[1], Kasey Schroeder[2], Jeffrey A. Golus[2], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (41)

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†Which Factor Influences Dicamba Volatility the Greatest: Soil, Foliage or Adjuvant? Jamie L. Long*, Bryan Young; Purdue University, West Lafayette, IN (43)

†Simulated Tank Contamination of 2,4-D with Combinations of Dicamba and Glyphosate Applied to Dicamba Tolerant Soybeans. Brent C. Mansfield*, Marcelo L. Moretti, Bryan Young; Purdue University, West Lafayette, IN (44)

Sprayer Clinics: Adding to the Agronomy Toolbox. David J. Palecek*; Winfield United, River Fs, WI (45)

†Change in Droplet Size from Plugged Air Induction Ports on Venturi Nozzles. Débora de Oliveira Latorre*[1], Thomas R. Butts[1], Jesaelen G. Moraes[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (46)

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†Application Timing of PPO-inhibitor Herbicides Influences Level of Palmer Amaranth Control. Larry J. Rains*[1], Das Peterson[2]; [1]Kansas State Weed Science Dept., Manhattan, KS, [2]Kansas State University, Manhattan, KS (49)

Herbicide-Resistant Common Waterhemp and Palmer Amaranth in Wisconsin. Devin J. Hammer*, Nathan M. Drewitz, David E. Stoltenberg, Shawn P. Conley; University of Wisconsin-Madison, Madison, WI (50)

Weed Control Programs with Dicamba and Residuals in Dicamba Tolerant Soybeans. Jon E. Scott*, Stevan Knezevic; University of Nebraska-Lincoln, Concord, NE (51)

†Soybean Response to Current Herbicides. Crystal Dau*, Anita Dille; Kansas State University, Manhattan, KS (52)

Burndown of Glyphosate-Resistant Marestail in Northeast Nebraska. Jon E. Scott*, Stevan Knezevic; University of Nebraska-Lincoln, Concord, NE (53)

An AirTractor 502 Simulator for Training Agricultural Aviation Pilots on Pesticide Applications. Jeffrey A. Golus*, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (54)

Simulated Drift of Dicamba on Potentiy Sensitive Crops. Stevan Knezevic*, Maxwel C. Oliveira, Jon E. Scott; University of Nebraska-Lincoln, Concord, NE (55)

Mobile Lab for Training Pesticide Applicators. Chandra J. Hawley*, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (56)

Alternatives to Glyphosate for Chemical Weed Control in Wheat Stubble. Das E. Peterson*, Curtis R. Thompson, Cathy L. Minihan; Kansas State University, Manhattan, KS (57)

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†Liquid Physical Properties and Droplet Size in Clethodim Applications. Marcella Guerreiro de Jesus*[1], Jesaelen G. Moraes[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (58)

Diverse Homoeolog Composition in ohexaploid Wild Oat as Evidenced by Plastidic ACCase Gene Sequences. Michael J. Christoffers*, Robert P. Sabba; North Dakota State University, Fargo, ND (59)

†Adjuvant Influence on Efficacy of Lactofen. Rodger Farr*, Kasey Schroeder, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (60)

Control of Glyphosate-resistant Horseweed (*Conyza canadensis*) with Halauxifen-methyl versus Dicamba and 2,4-D. Cara L. McCauley*, Bryan Young; Purdue University, West Lafayette, IN (61)

†Coevolution of Resistance to PPO Inhibitors in Palmer Amaranth and Waterhemp. Kathryn J. Lillie*[1], Darci Giacomini[1], James R. Martin[2], JD Green[3], Patrick Tranel[1]; [1]University of Illinois, Urbana, IL, [2]University of Kentucky, Princeton, KY, [3]University of Kentucky, Lexington, KY (62)

A Comparative Analysis of the Palmer Amaranth and Waterhemp Transcriptomes. Darci A. Giacomini*[1], Anita Kuepper[2], Todd A. Gaines[2], Roland Beffa[3], Patrick Tranel[1]; [1]University of Illinois, Urbana, IL, [2]Colorado State University, Fort Collins, CO, [3]Bayer CropScience, Frankfurt, Germany (63)

First Case of Glyphosate Resistance in Palmer Amaranth (*Amaranthus palmeri*) from Mexico. Javid Gherekhloo[1], Pablo T. Fernandez-Moreno*[2], Jose A. Dominguez-Valenzuela[3], Hugo E. Cruz-Hipolito[4], Reid Smeda[5], Rafael A. De Prado[2]; [1]Department of Agronomy, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran, Gorgan, Iran, [2]University of Cordoba, Cordoba, Spain, [3]Department of Agricultural Parasitology, Chapingo Autonomous University, Road México, Texcoco Km. 38.5, 56230 Texcoco, México, Texcoco, Mexico, [4]Bayer CropScience, Col. Ampl. Granada 11520, México D.F, México D.F, Mexico, [5]University of Missouri, Columbia, MO (64)

†Genetics of 2,4-D Resistance in an Illinois Waterhemp Population. Sebastián Sabaté*, Patrick Tranel, Aaron G. Hager; University of Illinois, Urbana, IL (65)

†High Temperature Enhances the Efficacy, Absorption and/or Translocation of 2,4-D or Glyphosate in Giant Ragweed. Zahoor A. Ganie*[1], Mithila Jugulam[2], Amit Jhala[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska Lincoln, Lincoln, NE (66)

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†Droplet Size and Deposition of Glyphosate and 2,4-D Drift in a Wind Tunnel. Matthew R. Nelson*, Bruno Canella Vieira, Annah Geyer, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (68)

†PPO-inhibitor-resistant Rigid Ryegrass (*Lolium rigidum*) and Wild Poinsettia (*Euphorbia heterophylla*) Response to Pre and Post Applied Oxyfluorfen. Pablo T. Fernandez-Moreno*[1], Reid Smeda[2], Rafael A. De Prado[1]; [1]University of Cordoba, Cordoba, Spain, [2]University of Missouri, Columbia, MO (69)

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†What is the Role of Crop Interference in Integrated Weed Management of Edamame? Laura Crawford*, Martin M. Williams; University of Illinois, Urbana, IL (70)

Bicyclopyrone: Major League Weed Control in Minor League Crops. Dain E. Bruns*[1], Cheryl L. Dunne[2], Gordon D. Vail[3], Monika Saini[3], Stott W. Howard[4]; [1]Syngenta Crop Protection, Marysville, OH, [2]Syngenta Crop Protection, Vero Beach, FL, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta Crop Protection, Des Moines, IA (71)

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†Cery Pear (*Pyrus ceryana*), an Invasive Urban Weed: Effective Control Methods. Matthew R. Terry*, Reid Smeda; University of Missouri, Columbia, MO (72)

A Simulation to Predict the Spread of Road Dust in a Crop Field and its Potential Effects on Palmer Amaranth. Sydney Rissler[1], Teig Loge*[2]; [1]Simpson College, Ankeny, IA, [2]Simpson College, Indianola, IA (73)

†A Regional Monitoring Program for Herbicide Resistance in Shattercane and Johnsongrass Following Commercialization of Inzen Sorghum Hybrids. Jake J. Ziggafoos*[1], Rodrigo Werle[2], Amit J. Jhala[3], John Lindquist[3], Brigitte Tenhumberg[1], Jeffrey Mower[1], Melinda Yerka[1]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE (74)

Weed Biology, Ecology, Management

†Effect of Growth Regulator Herbicide Injury to Common Milkweed on Ovipositioning by Monarch Butterflies. Brooke L. Hoey*, Sydney Lizotte-H, Bob Hartzler; Iowa State University, Ames, IA (75)

†Common Milkweed Injury due to Fomesafen Exposure and its Impact on Monarch Utilization. Sydney E. Lizotte-H*, Bob Hartzler; Iowa State University, Ames, IA (76)

Mechanisms of Weed Emergence Response to Tillage and Cover Cropping: Impacts of Herbicides and Fungal Pathogens. Markah Frost*, Daniel C. Brainard; Michigan State University, East Lansing, MI (77)

†Fitness Outcomes Related to Herbicide Resistance in Weeds: What Life History Stage to Examine? O. Adewale Osipitan*[1], Anita Dille[2]; [1]Agronomy Department, Kansas State University, Manhattan, KS, [2]Kansas State University, Manhattan, KS (78)

†Antagonistic Effect of Glyphosate and Dicamba Tank-mix on Kochia Control. Junjun Ou*[1], Curtis R. Thompson[1], Phillip W. Stahlman[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Research and Extension, Hays, KS (79)

†Environment and Hormone Effects on Seed Germination Behavior of Kochia. Anita Dille, Mithila Jugulam, Samida Khadka*; Kansas State University, Manhattan, KS (80)

†Effect of Common Ragweed (*Ambrosia artemisiifolia* L.) and Common Waterhemp (*Amaranthus rudis* Sauer) on Soybean (*Glycine max* L.) Growth. Koffi Badou Jeremie Kouame*; University of Nebraska-Lincoln, Lincoln, NE (81)

Distribution of Glyphosate-resistant Giant Ragweed (*Ambrosia trifida* L.) in Nebraska. Lia Marchi Werle*[1], Spencer L. Samuelson[2], Greg R. Kruger[2]; [1]University of Nebraksa-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE (82)

†Impact of Rainf on Residual Activity of Dicamba on Foxtail (*Setaria spp.*) and Morningglory (*Ipomoea spp.*) Germination and Growth. en J. Scott*, Carey Page, Reid Smeda; University of Missouri, Columbia, MO (83)

†Response of Waterhemp Populations from Nebraska to Soil Applied PSII and PPO Herbicides. Felipe Faleco*[1], Bruno Canella Vieira[2], Spencer L. Samuelson[2], Liberty Butts[2], Greg R. Kruger[2], Rodrigo Werle[2]; [1]Sao Paulo State University, Botucatu, Brazil, [2]University of Nebraska-Lincoln, North Platte, NE (84)

†Palmer Amaranth (Amaranthus palmeri) Suppression with Half Rates of Dicamba and Atrazine with Increasing Sorghum (Sorghum bicolor) Density and Nitrogen Rate. IVAN B. Cuvaca*[1], Rand S. Currie[2], Mithila Jugulam[1], Anserd Foster[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Univ., Garden City, KS, [3]Kansas State University, Garden City, KS (85)

†Does Road Dust have the Potential to Impact Chemical Control of Waterhemp (*Amaranthus tuberculatus*)? Kayla Price*, Clint K. Meyer, Zoe G. Muehleip, Maggie E. Long, Rick Spellerberg; Simpson College, Indianola, IA (86)

†Density Dependent Johnsongrass (*Sorghum halepense*) Seed Production. Don G. Treptow*; University of Nebraska - Lincoln, Ithaca, NE (87)

†Quantifying the Origin of Resistance. Federico Casale*[1], Patrick Tranel[2]; [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University of Illinois, Urbana, IL (88)

†Understanding Gender Determination In Dioecious Amaranthus Weeds. Ahmed Sadeque*[1], Patrick Brown[2], Patrick Tranel[3]; [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Illinois at Urbana-Chamapaign, Urbana, IL, [3]University of Illinois, Urbana, IL (89)

†Investigations of 2,4-D and Multiple Herbicide Resistance in a Missouri Waterhemp Population. Blake R. Barlow*, Meghan Biggs, Mandy Bish, Kevin Bradley; University of Missouri, Columbia, MO (90)

Analysis of Weed Species Spectrum After a Four Year Corn and Soybean Rotation With Growth Regulator Herbicide Dependent Weed Control Programs. Travis Legleiter*, William G. Johnson; Purdue University, West Lafayette, IN (91)

†Distribution of Glyphosate-resistant Common Waterhemp (*Amaranthus rudis*) in Nebraska. Bruno Canella Vieira*[1], Spencer L. Samuelson[1], Jose H. Sanctis[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]ESALQ-USP, Sao Paulo, Brazil (92)

†Response of Palmer Amaranth (*Amaranthus palmeri*) to Glyphosate and PPO-inhibiting Herbicide Tank-mixtures. Jesaelen G. Moraes*[1], Thomas R. Butts[2], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (93)

†Control of Palmer amaranth (*Amaranthus palmeri*) and Common Lambsquarters (*Chenopodium album*) with Tank-mixtures of Clethodim and Dicamba. Andrea Rilakovic*, Isidor Ceperkovic, Kasey Schroeder, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (94)

†Development of Codominant Markers for Amaranthus Species Identification. Brent P. Murphy*, Patrick Tranel; University of Illinois, Urbana, IL (95)

†Response of Nebraska Horseweed (*Conyza canadensis*) Populations to Lactofen and Cloransulam-methyl. Estefânia Gomiero Polli*, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (96)

Ability of *Clavibacter michiganensis* subsp. *nebraskensis*, Causal Agent of Goss's Wilt of Corn, to Overwinter in Alternative Host Debris and Seed. Joseph T. Ikley*[1], William G. Johnson[2], Kiersten A. Wise[1]; [1]Purdue University, LAFAYETTE, IN, [2]Purdue University, West Lafayette, IN (97)

†Survey of Field Practices, Environmental Factors, and Alternative Weed Hosts Influencing the Occurrence of Goss's Wilt. Taylor M. Campbell*[1], Joseph T. Ikley[2], Kiersten A. Wise[2], William G. Johnson[3]; [1]Purdue University, Lafayette, IN, [2]Purdue University, LAFAYETTE, IN, [3]Purdue University, West Lafayette, IN (98)

†Seasonal Changes in Forage Quality of Common Pasture Weeds in Missouri. Zach L. Trower*[1], Mandy D. Bish[2], Meghan Biggs[1], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (99)

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Abstracts

UTILIZING GEOSPATIAL TECHNOLOGY TO EVALUATE OFF-TARGET DICAMBA INJURY AND YIELD LOSS IN MISSOURI SOYBEAN FIELDS. Shea T. Farrell*[1], Kent Shannon[1], Eric G. Oseland[1], Mandy D. Bish[2], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO

In 2016, the majority of the cotton acreage in the mid-South were planted with dicamba-tolerant (DT) varieties, and a limited number of DT soybean varieties were also planted in the mid-South and Midwest. However, during the 2016 growing season, the Environmental Protection Agency had not approved any dicamba herbicide formulations for post-emergence application to these varieties. Although investigations are ongoing, apparently some subset of growers made illegal applications of dicamba to their DT cotton and/or soybean, which resulted in off-target movement of dicamba to a variety of sensitive crops, including non-DT soybean. In southeastern Missouri alone, over 125 dicamba injury complaints were filed with the Missouri Department of Agriculture. In non-DT soybean, previous and extensive research has been conducted that identifies specific yield losses to the dose of dicamba and the stage of the non-DT soybean plants when contacted. However, in field settings, practitioners never know the specific dose of dicamba that contacted the non-DT soybean. Additiony, plants may be injured multiple times by more than one off-target dose of dicamba, as occurred in southeast Missouri during the 2016 season. These factors complicate estimations of soybean yield loss. The objective of this research is to correlate field-scale, visual ratings of dicamba injury to the actual yield losses observed using geospatial technology. In 2016 four separate non-DT soybean fields that were reported to have been injured by off-target movement of dicamba were visuy rated for dicamba injury using a previously established scale developed by Richard Behrens and W. E. Lueschen (1979). The fields ranged in size from 30.35 to 47.75 ha. Field boundaries were mapped and uploaded to SMS Mobile Ag Leader software for sample grid creation. Sample locations were established within each field using a center grid format at spacings of 25 m. Handheld GPS units were used to navigate to the predetermined grid locations and record visual soybean injury ratings. This amounted to 472, 273, 357, and 352 observations taken in the 30.35-ha, 37.23-ha, 42.09-ha, and 47.75 ha fields, respectively. Site-specific yield information was then obtained through combine yield monitors. Soybean yield at each predetermined grid location was extracted from the yield monitor software and used to determine if field-scale visual observations of dicamba injury are correlated with actual yield loss. Results from this study will help farmers and agricultural professionals to better visualize and understand the effects that off-target movement of dicamba can have on soybean yield.

PREEMERGENCE ACTIVITY OF CHLOROACETAMIDE HERBICIDES ON A MULTIPLE HERBICIDE-RESISTANT POPULATION OF WATERHEMP (*AMARANTHUS TUBERCULATUS*). Seth A. Strom*, Aaron G. Hager, Dean Riechers; University of Illinois, Urbana, IL (1)

Chloroacetamide herbicides, either alone or paired with another soil-residual herbicide, are an integral part of pre-emergence (PRE) herbicide programs in corn and soybean. Field experiments during the summer of 2016 were designed to characterize and differentiate the PRE activity of several very-long-chain fatty acid synthesis-inhibiting herbicides on a multiple-resistant population of waterhemp (*Amaranthus tuberculatus*) through conducting two separate bare-ground studies. The over objective was to identify which variable causes the largest difference in PRE activity of acetochlor versus *s*-metolachlor in these waterhemp populations based on observations in previous years. Eight different Group 15 herbicides were compared at labeled rates for their PRE control of waterhemp, and a rate titration study was used to quantify the differences in activity between acetochlor and *s*-metolachlor in the same waterhemp population. Results indicated that acetochlor provided the highest over PRE control of waterhemp among herbicides examined and importantly a drastic difference was noted between acetochlor versus *s*-metolachlor at each rate tested. Greenhouse experiments have been set up to further investigate these field observations and begin to test the hypothesis that a plant-related factor such as metabolism may be the primary reason for results recorded during the 2016 growing season.

EVALUATION OF POST-EMERGENCE HERBICIDES FOR MANAGING HORSEWEED (*CONYZA CANADENSIS*) IN CORN. Chris Proctor*, Amit Jhala; University of Nebraska Lincoln, Lincoln, NE (2)

Glyphosate-resistant horseweed (*Conyza canadensis*) is a growing problem for corn and soybean growers in Nebraska and several other states in the Midwest. As glyphosate-resistant horseweed populations increases it is common for herbicide applications to fail where they were successful the previous year. Additiony, growers may miss the ideal window for herbicide control of horseweed due to unfavorable weather conditions and have to rely on rescue POST herbicide applications after planting crops. The chenge with rescue herbicide applications is weeds will often grow larger than the ideal size between the initial (or missed) and rescue application. This puts additional pressure on the rescue treatment and may result in a second (failed) herbicide application. The objectives of this study was to evaluate the efficacy of several POST herbicides for control of glyphosate-resistant horseweed after bolting in emerged (v3) corn (*Zea mays*), and their effect on corn yield. Research was conducted in 2016 under rain-fed conditions near Lincoln, Nebraska. Corn was planted on April 26, the first POST herbicide application was made on May 14, and a late blanket herbicide (dicamba + tembotrione) application was made on June 15, 2016. Dicamba + tembotrione (DiflexxDUO), diflufenzopyr + dicamba (Status), and fluthiocet + mesotrione (Solstice) + atrazine, and bromoxynil (Buctril) + atrazine or dicamba provided > 72% control 25 d after treatment (DAT). The second POST rescue application of dicamba + tembotrione applied at v8 corn resulted in 20 to 90% horseweed control compared with untreated control at 39 DAT and >90% control when dicamba or dicamba based tank-mixtures herbicides were applied before. This treatment combination resulted in >7400 kg ha^{-1} corn yield under rainfed conditions. No corn injury was observed in any herbicide treatments. Results suggest that horseweed is sensitive to dicamba and can be controlled with rescue two-pass POST applications.

EFFECTS OF CLETHODIM AND DICAMBA TANK-MIXTURES ON CONTROL OF VOLUNTEER CORN (*ZEA MAYS*) AND GRAIN SORGHUM (*SORGHUM BICOLOR*). Isidor Ceperkovic*, Andrea Rilakovic, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (3)

Clethodim and dicamba are used to for control grass and broadleaf weeds in crops. When used in a tank-mixture, there is a possibility of antagonistic or synergistic interactions between these two herbicides. The objective of this research was to determine if there are any interactions when clethodim and dicamba are used in tank-mixture to control volunteer corn (*Zea mays*) and grain sorghum (*Sorghum bicolor*). The experiment was conducted in a greenhouse in a completely randomized design, and plants were grown to a height of 10-15 cm. A single nozzle track sprayer was used to apply 49 treatments with four repetitions spatiy and two trials. The treatments included combinations of seven rates (0, 0.25, 0.5, 1, 2, 4 and 8x) of both herbicides where a 1x for clethodim was 0.13 kg ai ha^{-1} and 1x for dicamba is 0.28 kg ae ha^{-1}. After applications, plants were kept in the greenhouse and visual estimations of control were taken on 7, 14, 21 and 28 d after application. After the last evaluation, plants were harvested, dried to constant mass, and dry biomass was recorded. Data from 14 d after application were fit to a nonlinear regression model with the drc package in R 3.1.2. The estimated effective dose to control volunteer corn and sorghum by 50 and 90% were estimated for each population using a four parameter log logistic equation: y=c+(d-c/1+exp(b(log x -log e))). ED_{50} and ED_{90} for clethodim at rate 1x were 0.012 kg ai ha^{-1} and 0.044 kg ai ha^{-1} and increased 0.032 g ae ha^{-1} when dicamba was added at 0.28kg ae ha^{-1}. Grain sorghum data showed neither antagonistic nor synergistic interactions between clethodim and dicamba. Volunteer corn data showed some signs of antagonistic interaction. ED_{50} and ED_{90} for clethodim were higher as the dose of dicamba was increased.

GRAIN SORGHUM RESPONSE TO HUSKIE™ FOLLOWING TREATMENT WITH HERBICIDE MIXTURES CONTAINING MESOTRIONE. Seth Menzer*, Mithila Jugulam, Curtis R. Thompson; Kansas State University, Manhattan, KS (4)

Options for rotating herbicide modes-of-action for post-emergence (POST) weed control are limited in grain sorghum. Huskie™ is a product that combines bromoxynil (PSII-inhibitor) with pyrasulfotole (HPPD-inhibitor) at a ratio of 1:5.65 for broad-spectrum weed control. However, growers are warned on the label that unacceptable injury may occur if Huskie™ is applied to acreage previously treated with any product containing mesotrione, another HPPD-inhibiting herbicide. The objective of this study was to determine whether Huskie™ treatments following application of products containing mesotrione did indeed result in unacceptable sorghum injury and reduce grain yields. Trials were conducted at Ashland Bottoms near Manhattan, KS in 2015 and 2016 and at the Southwest Research Extension Center near Tribune, KS in 2016. Pre-emergence (PRE) applied treatments with mesotrione were Lexar® EZ (atrazine & *s*-metolachor & mesotrione ratio 7.9:7.9:1) at 3114 g ai ha^{-1}, Lumax® EZ (atrazine & s-metolachor & mesotrione ratio 10:3.76:1) at 2778 g ai ha^{-1}, and Zemax® (*s*-metolachor & mesotrione ratio 11:1) at 2061 g ai ha^{-1}. The PRE applied herbicide without mesotrione was *S*-metolachlor&atrazine (1:1.29 ratio) applied at 3248 g ai ha^{-1}. The PRE treatments were applied alone or were followed by POST applied Huskie™ at 235 or 288 g ai ha^{-1} + atrazine at 560 g ai ha^{-1}, or bromoxynil at 280 g ai ha^{-1} + atrazine at 560 g ai ha^{-1}. POST treatments at the discussed rates were also applied to sorghum without the previous PRE treatments. Crop response was rated 3, 7, 14 and 28 d after POST treatment (DAT), and sorghum was harvested at physiological maturity for yield. Results demonstrated greater sorghum injury in plots treated with Huskie™ + atrazine than those treated with bromoxynil + atrazine three DAT, but no difference was observed among Huskie™ treatments that followed PRE mesotrione treatment. No injury was observed for any treatment 28 DAT. Sorghum yields were similar among treatments and was not reduced when Huskie™ was applied to sorghum previously treated with herbicides containing mesotrione. The potential to apply Huskie™ following PRE treatments containing mesotrione adds an important tool for season-long weed control in sorghum.

CRITICAL PERIOD OF GRASS WEED CONTROL IN ALS-RESISTANT SORGHUM. Jeffrey J. Albers*[1], Anita Dille[1], Curtis R. Thompson[1], Phillip W. Stahlman[2]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Research and Extension, Hays, KS (5)

ALS-resistant grain sorghum hybrids have recently been developed by DuPont Crop Protection. This new technology allows a POST grass control option in grain sorghum production with an application of a sulfonylurea (nicosulfuron) herbicide. Before this technology, not many effective POST grass control options were available in grain sorghum. The objective of the study is to determine the critical period of grass weed control in a grain sorghum crop. Field experiments were conducted in 2016 at Hays and Manhattan, KS with 11 different treatments. A single Inzen™ sorghum hybrid was used for both sites. Four of the treatments were plots kept weed-free until 2, 3, 5, and 7 wk after crop emergence, after which grass weeds were owed to grow and compete with the sorghum. Four other treatments had weed removal at 2, 3, 5, and 7 wk after crop emergence, where no weed control was implemented until the treatment week and then plots were kept weed-free for the duration of the season. The remaining three treatments were a PRE herbicide application of (s-metolachlor + atrazine); a hand weeded weed-free season plot, and an untreated plot with no grass weed control. Each week, inside two $0.03m^2$ rings, grass weeds were counted, and height measured in each plot. Also, the weed-free treatments were applied as a directed application of glufosinate herbicide with a hooded sprayer. At 50% bloom, weed biomass and sorghum biomass were harvested from 1 m row. The total fresh weight was measured and two plants were separated into leaves, stems, and heads. The biomass from the leaves, stems, and heads was dried and weighed. Since a sterile grain sorghum hybrid was used and no grain was produced, the study concluded with biomass harvest. Slight treatment differences were seen in the amount of grain sorghum biomass produced. The general trend shows a deduction in biomass as the duration of weed competition increased. Additiony the general trend showed an increase in biomass as the weed-free duration increased.

BIOCHEMICAL ANALYSIS AND TRANSCRIPT PROFILING OF ETIOLATED SORGHUM COLEOPTILES FOLLOWING SAFENER OR OXYLIPIN TREATMENT.
Rong Ma*[1], Patrick J. Brown[2], Kris N. Lambert[2], Anatoli V. Lygin[2], Mayandi Sivaguru[2], Stephen P. Moose[2], Dean E. Riechers[2]; [1]UIUC, Urbana, IL, [2]University of Illinois, Urbana, IL (6)

Safeners protect cereal crops from herbicides by inducing detoxification systems, including the dramatic enhancement of glutathione *S*-transferases (GSTs) activity. Previous research indicated the outermost cells of wheat (*Triticum tauschii*) coleoptiles show massive accumulations of immunoreactive GST protein following safener treatment. Oxylipins (such as A_1-type phytoprostanes, PPA_1) are generated from membrane-derived linolenic acid via lipase activity or non-enzymatic oxidation under stressful conditions and strongly induce genes involved in plant defense and detoxification reactions in *Arabidopsis*. Thus our research objectives were to compare (1) transcript profiles in sorghum (*Sorghum bicolor*) coleoptile sections and (2) *in vitro* GST activity (using metolachlor as substrate and intact seedlings) in response to either safener or PPA_1. A novel cryostat-microtome sectioning method was developed to extract high-quality total RNA from the outermost cells of coleoptiles (excluding leaf tissues) for transcript profiling. RNAseq results identified > 10-fold increases in transcripts of several detoxification genes, including multiple *GSTs*, *P450s*, and glycosyltransferases, in safener or PPA_1 treated seedlings compared with untreated controls. Moreover, transcripts encoding proteins related to plant development and defense such as lipases, cytokinin metabolism, and gibberellin signaling were upregulated > eight-fold following safener or PPA_1 treatment. GST activity following safener treatment increased up to 6.2-fold in a linear fashion between eight and 48 HAT but remained consistently low in untreated controls. PPA_1 ly increased GST activity at two HAT but not in later time points, implying oxylipin involvement in fatty acid-regulated signaling for GST induction. GST activity was also examined in three sorghum lines varying in basal or safener-increased *s*-metolachlor tolerance. Results indicated higher GST activity in three lines following safener treatment than untreated controls at 12 HAT but not at four HAT. Future research will quantify the expression of specific *SbGSTs* via qRT-PCR as well as other genes related to detoxification and plant defense identified by RNAseq to better understand safener-regulated signaling mechanisms.

WEED CONTROL IN SPRING MALTING BARLEY.
Alyssa Lamb*[1], Mark M. Loux[1], Tony Dobbels[2]; [1]The Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH (7)

A field study was conducted in 2016 to determine the efficacy of PRE and POST herbicides for control of weeds in spring barley. This study was conducted to provide information to the malting barley growers in Ohio, due to the lack of information on weed control in spring-planted sm grains here. Barley was planted on March 22 and April 19 into tilled seedbeds, and PRE herbicides applied the d after planting. POST herbicides were applied on May 19 when giant foxtail and common lambsquarters were less than 8 cm t. Giant ragweed was up to 23 and 10 cm t for the first and second planting, respectively. Treatments included: PRE application of saflufenacil at 50 g ai ha^{-1} alone; PRE saflufenacil followed by POST application of various grass and broadleaf herbicides; and POST application of various grass and broadleaf herbicides without a prior PRE. Crop injury was not observed for any herbicide treatment. Just prior to harvest, PRE application of saflufenacil controlled 100% of common lambsquarters, no more than 50% control of giant foxtail, and 95 and 27% control of giant ragweed in the first and second planting, respectively. Giant ragweed control in both plantings was improved to 98 to 100% by any POST herbicide treatment that had substantial activity on this weed. The PRE/POST or POST treatments that included pinoxaden controlled 87 to 100% of giant foxtail. While some differences in yield occurred among treatments for the first planting, these did not appear to reflect differences in efficacy, especiy given the number of treatments that provided complete or near complete control. Spring barley growers have a number of effective herbicide options for control of the primarily summer annual weeds that can be present with little risk of crop injury. Results of this study would also appear to indicate that planting earlier in spring can help maximize control of certain early-emerging weeds such as giant ragweed, especiy for PRE applications of saflufenacil that are not followed with a POST application of broadleaf herbicide.

WEED CONTROL IN FIELD PENNYCRESS.
Logan H. Bishop*[1], Dr. Kelly Nelson[2]; [1]Universtiy of Missouri - Columbia, Columbia, MO, [2]University of Missouri - Columbia, Columbia, MO (8)

Field pennycress (*Thlaspi arvense* L.) has the potential to serve as a cover crop and an oilseed crop for biofuel production. Field research was conducted near Novelty and Leonard, Missouri. The objective of this research was to determine tolerance of field pennycress to pre-emergence herbicides and control of other weed species. The experiment was arranged as a randomized complete block design with four replications including 11 pre-emergence herbicides at two rates and a non-treated control. 'Adams' was broadcast seeded at Leonard and drill seeded at Novelty at 30 kg ha^{-1}. Pennycress injury and weed control were visuy evaluated once a week until pennycress maturity. A species count and biomass sample from each plot was determined at each location. Pennycress had some tolerance to simazine (2.24 kg ai ha^{-1}) and pendimethalin (4.26 kg ai ha^{-1}) at half of the labeled rate while there was tolerance to *S*-metolachlor (8.56 kg ai ha^{-1}), metribuzin (0.84 kg ai ha^{-1}), and dimethenamid-*P* (6.72 kg ai ha^{-1}) at the labeled rate while still having control of shepherd's purse [*Capsella bursa-pastoris* (L.) Medicus*]* and common lambsquarters (*Chenopodium album* L.) at Novelty. At Leonard, there was some tolerance to simazine (2.24 kg ai ha^{-1}) at a half rate with moderate control of annual bluegrass (*Poa annua* L) and mustard (*Sinapis arvensis* L.). The 'Adams' selection of pennycress was used for this research, but it seemed to behave similar to a "wild type" with dormancy and plant uniformity being a chenge in this research.

PREHARVEST HERBICIDE EFFECTS ON WINTER WHEAT. Kelsey M. Rogers*[1], Christy L. Sprague[2]; [1]Michigan State University, Lansing, MI, [2]Michigan State University, East Lansing, MI (9)

Weeds continue to be common in many winter wheat fields at harvest. Late plantings due to delays in previous crop harvesting and earlier winters do not bode well for good establishment of wheat. In addition, wetter than normal springs can narrow the window for spring herbicide applications and in some cases prevent them. A field experiment was conducted at the Michigan State University Agronomy Farm in 2015 and 2016 to evaluate the effect of preharvest herbicide applications on winter wheat. Preharvest herbicide treatments included: dicamba, 2,4-D amine, carfentrazone, saflufenacil, glyphosate, and glyphosate in combination with carfentrazone and saflufenacil. Applications were made when wheat was physiologicy mature (<30% moisture). In 2016, two additional treatments of glyphosate at 0.84 and 1.68 kg ae ha^{-1} were included and applied at an earlier application time when grain moisture was ~40%. Treatments were compared to a nontreated control. In 2015, common lambsquarters and common ragweed desiccation were evaluated 3, 7, 10 and 15 d after treatment (DAT). Plots were harvested, each plot was assigned a harvestability score, and yield was recorded. Lower weed populations in 2016 prevented the evaluation of weed desiccation and wheat harvestability. Wheat grain samples were collected to measure grain moisture, test weight, percent foreign material, weight of 100 seeds and wheat seed viability. Herbicide residue levels were tested in grain treated with glyphosate in 2016. Saflufenacil alone and in combination with glyphosate provided > 85% common ragweed desiccation three DAT in 2015. other treatments did not adequately desiccate common ragweed, with the exception of glyphosate and glyphosate combinations. However, these applications needed 15 d for maximum desiccation. Glyphosate and glyphosate combinations were the only treatments that provided adequate desiccation of common lambsquarters 15 DAT. Harvestability scores were also highest with treatments containing glyphosate in 2015. These treatments also resulted in the highest test weights, lowest grain moistures and lowest amount of foreign material in the harvested crop. In 2016, regardless of treatment there were no difference in any of the grain parameters measured compared with the nontreated control. Preharvest treatments had little effect on wheat yield in both seasons. Glyphosate residues were magnitudes different based on application rate and application timing. The highest glyphosate residue level found in the grain was 796 ppb,when glyphosate was applied at two-times the normal application rate and applied prior to physiological maturity (39% grain moisture). This glyphosate level was 37.5 times lower than the maximum residue level owed in wheat. Data from this research suggests that of the potential preharvest herbicides for use in wheat, glyphosate and glyphosate combinations were the only treatments that resulted in over effective weed desiccation, improved wheat harvestability, and reduced factors that can lead to dockages at the point of sale.

EFFICACY OF VARIABLE RATE SOIL-APPLIED HERBICIDES BASED ON SOIL ELECTRICAL CONDUCTIVITY AND ORGANIC MATTER DIFFERENCES. Garrison J. Gundy*, Anita Dille, Antonio R. Asebedo; Kansas State University, Manhattan, KS (10)

Soil application of herbicides for preemergence (PRE) weed control in grain sorghum is not a new technology but has become vital in effectively controlling herbicide-resistant weeds. Efficacy of soil-applied herbicides is greatly influenced by soil properties including soil organic matter (SOM) and texture due to adsorption that impacts bioavailability. Herbicide labels provide multiple application rates based on soil properties that are variable in many fields. With precision agriculture technologies, variable rate applications (VRA) can be utilized to maximize herbicide effectiveness while minimizing their negative impacts on the crop and environment. In 2016, two locations in Kansas (Hutchinson and Salina) were used to develop procedures for effective application of VRA PRE herbicides based on SOM and apparent soil electrical conductivity (EC_a) collected by a Veris MSP3 soil mapping system. Two different tank-mixtures were applied, including s-metolachlor, mesotrione, and atrazine or saflufenacil, dimethenamid-P, and atrazine were applied. Two algorithms were developed for each tank mixture to determine the rate to apply to each plot and were based on SOM only or a combination of SOM and EC. A uniform flat rate of each tank mixture was applied based on mesotrione or saflufenacil usage rate for average soil properties. Seven total treatments were replicated across nine blocks to encompass observed soil variability. Visual ratings were taken weekly and compared to high-resolution images from sm unmanned aircraft systems (sUAS) from each plot. In Salina, treatments provided excellent control of Palmer amaranth four wk after treatment (WAT). By eight WAT, over weed control was reduced, but treatments provided the same amount of control. In Hutchinson, tank mixtures of s-metolachlor, mesotrione, and atrazine provided better control than both VRA applications of saflufenacil, dimethenamid-P, and atrazine at four WAT. The uniform flat rate application of saflufenacil, dimethenamid-P, and atrazine tank mixtures provided better control than both VRA applications. Grain yield was not affected by treatment across both locations.

INTEGRATION OF RESIDUAL HERBICIDES AND COVER CROPS FOR WEED CONTROL IN A SOYBEAN PRODUCTION SYSTEM. Derek M. Whalen*[1], Mandy D. Bish[2], Meghan Biggs[1], Eric Oseland[1], Zach Trower[1], Blake R. Barlow[1], Shea Farrell[1], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (12)

Cover crops have increased in popularity in Midwest corn and soybean production systems in recent years. One of the potential benefits that cover crops can provide is to reduce weed emergence or growth through the release of elopathic volatile chemicals into the weed rooting zone and/or through the creation of a physical mulch barrier. However, little research has been conducted to evaluate how cover crops and pre-emergence, residual herbicides are most appropriately integrated together in a soybean production system. Field studies were conducted in 2016 to evaluate summer annual weed control in response to six different cover crops combined with herbicide applications, which consisted of pre-plant applications of glyphosate plus 2,4-D with or without sulfentrazone plus chlorimuron. Pre-plant applications were made at two different timings, 21 and seven d prior to planting. The cover crops evaluated in the study included hairy vetch, cereal rye, Italian ryegrass, oats, Austrian winter pea, wheat and a mixture of hairy vetch and cereal rye. These same herbicide treatments were applied to tilled and non-tilled soil without any cover crop for comparison. Visual ratings of weed control, groundcover and cover crop control were taken at regular intervals after planting. Weed density counts were conducted when soybean reached R5. Data were subjected to analysis using the PROC GLIMMIX procedure in SAS, and means were separated using Fisher's Protected LSD ($P \leq 0.05$). In-season weed control ratings of treatments were taken seven wk after planting. Preliminary results indicate across treatments, herbicide applications in which a residual was included achieved greater than 88% control of weeds and were higher than the non-treated and glyphosate plus 2,4-D treatments alone. When evaluating cover crop species across treatments, those that included Italian ryegrass had the highest in-season weed control (90.4%) which was similar to oats and wheat but greater than other cover crops tested. One possible reason for the higher weed control in Italian ryegrass plots may be due to the regrowth of this species. Weed density counts were conducted in August when soybean reached R5. Preliminary results did not suggest interactions between cover crop and herbicide on end-of-season weed control. Treatments that included a residual herbicide application, independent of cover crop, had less than five weeds m^{-2} compared to more than 40 weeds m^{-2} in non-treated and treatments lacking residual herbicide applications. Results from this ongoing work will provide useful information on integrating cover crops and residual herbicides with soybean production.

DUPONT HERBICIDE PROGRAMS FOR CONVENTIONAL-TILL DICAMBA-TOLERANT SOYBEANS. Keith A. Diedrick*[1], Kelly A. Backscheider[2], Eric Castner[3], Richard Edmund[4], Kevin L. Hahn[5], Robert Rupp[6], Dan Smith[7], Charles E. Snipes[8], Bruce V. Steward[9], Robert Williams[10], Victoria A. Kleczewski[11], Jeffery T. Krumm[12], Michael D. Meyer[13], Scott E. Swanson[14], Larry H. Hageman[14], Keith D. Johnson[15], Marsha J. Martin[16]; [1]DuPont Crop Protection, Madison, WI, [2]DuPont Crop Protection, Shelbyville, IN, [3]DuPont Crop Protection, Weatherford, TX, [4]DuPont Crop Protection, Little Rock, AR, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Edmund, OK, [7]DuPont Crop Protection, Madison, MS, [8]DuPont Crop Protection, Greenville, MS, [9]DuPont Crop Protection, Overland Park, KS, [10]DuPont Crop Protection, Raleigh, NC, [11]DuPont Crop Protection, Middletown, DE, [12]DuPont Crop Protection, Hastings, NE, [13]DuPont Crop Protection, Johnston, IA, [14]DuPont Crop Protection, Rochelle, IL, [15]DuPont Crop Protection, Grand Forks, ND, [16]DuPont Crop Protection, Columbus, OH (13)

Glyphosate-resistant weeds continue to present control chenges to growers, and dicamba-tolerant soybeans will provide a new tool for in-crop weed control in soybeans. DuPont is working to develop multiple-mode-of-action, residual weed control programs that include dicamba. In this poster we will show that various combinations of DuPont soybean herbicides provide growers with excellent common waterhemp (Amaranthus rudis), Palmer amaranth (Amaranthus palmeri), and giant ragweed (Ambrosia trifada) control in dicamba-tolerant soybeans.

EVALUATIONS OF DUPONT™ BASIS BLEND® PREEMERGENCE HERBICIDE ALONE AND IN TANK-MIX COMBINATIONS FOR USE IN BOLT™ TECHNOLOGY SOYBEANS. Nickolas D. Theisen*[1], Larry H. Hageman[2], Scott E. Swanson[2], Kelly A. Backscheider[3], Keith A. Deidrick[4], Kevin L. Hahn[5], David H. Johnson[6], Michael D. Meyer[6], Victoria A. Kleczewski[7], Jeffery T. Krumm[8], Marsha J. Martin[9], Bruce V. Steward[10]; [1]University of Wisconsin- Platteville, Platteville, WI, [2]DuPont Crop Protection, Rochelle, IL, [3]DuPont Crop Protection, Shelbyville, IN, [4]DuPont Crop Protection, DeForest, WI, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Johnston, IA, [7]DuPont Crop Protection, Middletown, DE, [8]DuPont Crop Protection, Hastings, NE, [9]DuPont Crop Protection, Columbus, OH, [10]DuPont Crop Protection, Overland Park, KS (14)

DuPont™ Basis® Blend herbicide (rimsulfuron + thifensulfuron) is registered for fow, preemergence, and post-emergence use in field corn, preplant use in soybeans, and up to zero-day plantback in Pioneer® brand soybeans with BOLT™ technology. With the introduction of Pioneer® brand soybeans with BOLT™ technology, which confers increased tolerance to sulfonylureas, there is interest in new uses of Basis® Blend in tank mixtures with other preemergence soybean herbicides. A preemergence field study was conducted at nine locations across the U.S. to evaluate unique combinations of Basis® Blend plus other herbicides for tolerance and weed control in soybeans with BOLT™ technology. Preemergence application of Basis® Blend with various tank mixed herbicides provided a wide spectrum of excellent control of many key weed species when used in combination with soybeans with BOLT™ technology. The soybeans also showed excellent tolerance to these preemergence treatments, as little to no injury was observed, at 14 or 28 DAT for Basis® Blend alone and when Basis® Blend was combined with various preemergence tank mixtures.

CRITICAL TIME FOR WEED REMOVAL IN SOYBEANS IS INFLUENCED BY SOIL APPLIED HERBICIDES. Maxwel C. Oliveira*, Jon E. Scott, Stevan Knezevic; University of Nebraska-Lincoln, Concord, NE (15)

From 2000-2010, the weed control in soybeans was based primarily on the POST applications of glyphosate based products, which caused a rapid increase in glyphosate-resistant weeds. Therefore, there is a need to diversify weed control programs and use pre-emergent (PRE) with alternative modes-of-action. The objective of our study was to evaluate the effects of PRE herbicides on critical time for weed removal (CTWR) in soybean. The experiments were conducted in 2015 and 2016 in a split-plot design of 14 treatments, two herbicide regimes (No PRE and PRE application of sulfentrazone plus imazethapyr) and seven weed removal times (V1, V3, V6, R2 and R5, weed free and weedy season long). There were statistical differences between the two years; therefore data are presented by year. In 2015, CTWR (based on 5% acceptable yield loss) was at V1 soybean stage. The PRE application of sulfentrazone plus imazethapyr (280 g ai ha^{-1}) delayed CTWR to V5 soybean stage. In 2016, soybean yield losses were not as high as in 2015 due to late crop planting. Therefore, the CTWR in 2016 started at V3 soybean stage without PRE herbicide. Application of PRE (210 or 420 g ai ha^{-1}) delayed the CTWR to R1 soybean stage. Delayed CTWR in 2016 is the artificial effect of the late crop planting, and the fact that early emerging weeds were controlled by cultivation for field preparation for soybean planting. The CTWR was different between the two years, but they clearly showed the benefit of using PRE herbicides, which will also reduce the need for multiple applications of glyphosate and provide additional modes-of-action for combating glyphosate-resistant weeds.

TANK MIX PARTNERS WITH PARAQUAT FOR ENHANCED GRASS CONTROL. Marsh M. Hay*, Das E. Peterson; Kansas State University, Manhattan, KS (16)

Paraquat is highly effective in controlling broadleaf weeds, including glyphosate- and ALS-resistant biotypes, but does not consistently control grass weeds. Idey, producers would prefer to control both grass and broadleaf weeds with a single herbicide application rather than multiple, sequential treatments in a burndown or fow situation. To improve grass weed efficacy of paraquat treatments, it may be necessary to add a tank mix partner. A field experiment was conducted in Manhattan, Kansas in 2016 to evaluate POST grass weed control of paraquat and glufosinate, eleven two-way mixtures containing paraquat, and two three-way mixes containing paraquat, glufosinate, and atrazine or metribuzin. Herbicide treatments were applied to 20-cm giant foxtail (SETFA) and 30-cm orange sorgo (SORSS) and visuy evaluated for percent control two wk after treatment. Paraquat provided 84% control of SETFA and 50% control of SORSS. Glufosinate had less than 80% control of both SETFA and SORSS. When paraquat and glufosinate were combined in a two-way mixture, control of both species was approximately 90.Control of both grass species was greater than 90% with two-way mixtures of atrazine or clethodim plus paraquat and 97% for a tank-mixture of metribuzin with paraquat. Three-way mixes of paraquat, glufosinate, and atrazine or metribuzin resulted in greater than 98% control of both species. The two-way mixture of paraquat and glyphosate resulted in 80% control of SETFA and less than 20% control of SORSS, indicating antagonism on grass control with that tank-mix combination. The remaining six two-way mixtures resulted in less than 75% control of SETFA and SORRS. The results of this experiment demonstrate the potential to increase the grass weed control of paraquat with tank mix combinations of glufosinate, atrazine, metribuzin, or clethodim. This experiment also illustrates need for further basic and applied research to refine paraquat tank mix recommendations.

COMPARISON OF WEED MANAGEMENT SYSTEMS IN SIX SOYBEAN TECHNOLOGIES. Matthew C. Geiger*[1], Karla L. Gage[2], Ronald F. Krausz[3]; [1]Southern IL University, Carbondale, IL, [2]Southern Illinois University, Carbondale, IL, [3]Southern Illinois University, Belleville, IL (17)

Weed management in soybean production has become increasingly difficult because of the proliferation of weeds resistant to multiple herbicide sites-of-action. Knowledge of field history and the presence of herbicide-resistant weed biotypes is crucial for the selection and placement of soybean technology. Field trials in Belleville, IL and Dowell, IL were established in 2016 to investigate the effectiveness of different weed management strategies in six different soybean systems: conventional, and soybeans tolerant to glufosinate, glyphosate (1st and 2nd generation), dicamba + glyphosate, and 2,4-D + glyphosate. Weed control strategies include preemergence (PRE) -only (flumioxazin at 77 g ai ha^{-1} + chlorimuron at 21 g ai ha^{-1} + pyroxasulfone at 98 g ai ha^{-1}; or sulfentrazone at 278 g ai ha^{-1} + cloransulam at 36 g ai ha^{-1} + pyroxasulfone at 149 g ai ha^{-1}), PRE followed by post-emergence (POST; correlating with respective soybean system) including or excluding a residual herbicide (acetochlor at 1267 g ai ha^{-1}), and POST-only including or excluding a residual herbicide. Visual herbicide efficacy ratings and crop injury were recorded at 14, 28, and 56 d after treatment (DAT), as well as weed counts at 30 DAT and at harvest. Results four wk after planting (WAP) were as follows: in Belleville, PRE-only treatments did not receive sufficient rainf for activation and controlled 79% of giant ragweed, 72% of common cocklebur, 74% ivyleaf morningglory, 85% of giant foxtail, and 88% of velvetleaf compared to 99%, 98%, 97%, 98%, and 97% of the respective weed species in a PRE followed by a POST herbicide program, regardless if the POST contained a residual herbicide. In Dowell, PRE-only treatments received sufficient rainf for herbicide activation resulting in 97% control of glyphosate-resistant (GR) common waterhemp and 82%

control of f panicum. In a PRE followed by POST system, GR common waterhemp control was 97% or greater and f panicum control was 98%. POST-only treatments controlled GR common waterhemp 90% to 92%. Results 10 WAP are as follows: in Belleville, PRE-only treatments controlled 50% of giant ragweed, 51% of common cocklebur, 41% of ivyleaf morningglory, 73% of giant foxtail, and 60% of velvetleaf compared to 99%, 98%, 96%, 99%, and 98% of the respective weed species in a PRE followed by a POST herbicide program, regardless if the POST contained a residual herbicide. In Dowell, a POST-only including acetochlor program controlled 76% of common waterhemp and 85% of f panicum; the latter values were increased to 85% and 98%, respectively, with the inclusion of a PRE. Control of f panicum with a PRE-only application was improved from 80% to 98% by the inclusion of a POST, regardless if the POST included acetochlor. Control of common waterhemp with a POST-only application was improved from 65% to 76% by the inclusion of acetochlor. Inconsistent control of PRE-only or POST-only herbicide programs, across both sites, suggests there is a risk associated with either of the latter herbicide programs. Regardless of soybean variety and site, consistent and adequate weed control was attained with the use of a PRE followed by POST herbicide program; supporting that the use of a soil applied herbicide followed by a properly timed POST application is a necessary tool for the management of both herbicide-susceptible and herbicide-resistant weed biotypes.

EFFECT OF SOIL APPLIED PROTOPORPHYRINOGEN OXIDASE INHIBITOR HERBICIDES ON SOYBEAN SEEDLING DISEASE SEVERITY. Nicholas J. Arneson*[1], Loren J. Giesler[1], Rodrigo Werle[2]; [1]University of Nebraska, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (18)

Weed management in soybean is becoming increasingly difficult as many weed species have evolved resistance to glyphosate and other herbicide modes-of-action. The use of herbicides with soil residual activity such as protoporphyrinogen oxidase inhibitors (PPOs) is recommended for the management of resistant weeds. However, soil applied PPO herbicides can result in seedling injury if environmental conditions are not favorable for crop establishment. Soybean seedling diseases caused by fungi and fungal-like organisms such as *Fusarium* spp., *Rhizoctonia solani*, and *Pythium* spp. can have measurable impacts on crop stand and yield. It is known that seedling damage may ow infection by soilborne plant pathogens, yet no previous studies have determined if there is a direct relationship between soil applied PPO applications and seedling disease severity. In 2016, a replicated field study was conducted at four sites in Nebraska: near Chapman, Clearwater, Cordova and Schuyler. Experimental design was a randomized complete block design with a 2×3×2 factorial that included: two cultivars (PPO sensitive and tolerant to sulfentrazone), three herbicides [glyphosate (GLY) alone, sulfentrazone + GLY tank-mixture, and flumioxazin + GLY tank-mixture], and two seed treatments (with and without fungicide) with four replications at each site. PPO injury on the cotyledon was observed at locations except Cordova. Root rot symptoms were observed at locations. At Cordova, there was a herbicide-seed treatment interaction ($P<0.01$) and a herbicide-cultivar interaction ($P<0.05$). With no seed treatment, the flumioxazin and sulftentrazone treatments resulted in 21 and 28 % increase in root rot severity compared to glyphosate. The fungicide seed treatment resulted in lower root rot severity compared to no fungicide for sulfentrazone. In the sensitive cultivar, the flumioxazin treatment resulted in 14 and 25 % increase in root rot severity compared to the sulfentrazone and glyphosate treatments, respectively. In the tolerant cultivar, the sulfentrazone treatment resulted in a 15 % increase in root rot severity compared to glyphosate. These results suggest that soil applied PPO herbicides are associated with greater root rot disease severity; however, this study needs to be repeated before conclusions can be drawn. As effective weed management continues to incorporate potentiy crop-damaging herbicides it is important to further investigate interactions between these and seedling diseases as well as the effect of fungicide seed treatments.

EFFECT OF TIME OF DAY ON EFFICACY OF SAFLUFENACIL TO CONTROL GLYPHOSATE-RESISTANT CANADA FLEABANE IN SOYBEAN. Nader Soltani*, Chris Budd, Peter H. Sikkema; University of Guelph, Ridgetown, ON (19)

Control of glyphosate-resistant (GR) Canada fleabane in soybean with glyphosate (900 g a.i. ha^{-1}) plus saflufenacil (25 g a.i. ha^{-1}) has been variable. The objective of this research was to determine the effect of GR Canada fleabane height and density, and time of day (TOD) at application on saflufenacil plus glyphosate efficacy in soybean. experiments were completed six times during a two-year period (2014, 2015) in fields previously confirmed with GR Canada fleabane. Applications from 09:00- 21:00 h provided optimal control of GR Canada fleabane 8 WAA. Soybean yield pareled GR Canada fleabane control with the highest yield of 3.0 t ha^{-1} at 15:00 h, and the lowest yield of 2.4 t ha^{-1} at 06:00 h. The height and density of GR Canada fleabane at application had minimal effect on saflufenacil efficacy. Saflufenacil provided >99% control of GR Canada fleabane when applied to sm plants and low densities; however, control decreased to 95% where the weed was >25 cm t, and to 96% in densities >800 plants m^{-2} at 6 WAA due to some plant regrowth. TOD of application had a greater influence on GR Canada fleabane control with saflufenacil than height or density. To optimize control of GR Canada fleabane, saflufenacil should be applied during daytime hours to sm plants at low densities. Optimizing GR Canada fleabane control minimizes weed seed return and weed interference.

SOYBEAN INJURY FROM DICAMBA AND 2,4-D TANK CONTAMINATION. Nader Soltani*[1], Robert E. Nurse[2], Peter H. Sikkema[1]; [1]University of Guelph, Ridgetown, ON, [2]Agriculture Canada, Harrow, ON (20)

The anticipated availability of dicamba- and 2,4-D-resistant crops will increase the potential for crop injury to non-dicamba or 2,4-D-resistant soybean due to dicamba or 2,4-D spray tank contamination. A total of sixteen field trials (8 separate trials with each herbicide) were conducted in a completely randomized block design with four replications in Ontario, Canada during 2012-2014 to determine the response of non-dicamba and 2,4-D-resistant soybean to dicamba or 2,4-D spray tank contamination of 0.25, 0.5, 1.0 2.5, 5, 10 and 20% vv^{-1} tank contamination applied post-emergence (POST) at the V2-3 (2-3 trifoliate) or R1 (1st flower) stage. Dicamba applied at R1 caused 23, 28, 36, 40, 48, 61 and 73% visible injury in soybean at 0.75, 1.5, 3, 6, 15, 30 and 60 g a.e. ha^{-1}, respectively. The predicted dose of dicamba to reduce soybean seed yield 1, 5, 10, 20 or 50% was 1.1, 5.8, 11.8, 25.2 and >60 g a.e. ha^{-1} when applied at V2-3 and <0.75, 1.0, 2.0, 4.3 and 11.5 g a.e. ha^{-1} when applied at R1, respectively. There was no difference in soybean injury between V2-3 and R1 stages from 2,4-D spray tank contamination. There was a drop in seed yield at 84 and 168 g a.e. ha^{-1} contamination doses; however, there was no differences for any the yield components including soybean pods per plant, seeds per pod, seeds per plant and 100 seed weight. The predicted dose of 2,4-D to reduce soybean seed yield 1, 5, 10, 20 or 50% was 4.5, 22, 46, 97 and >168 g a.e. ha^{-1}. Results show that dicamba spray tank contamination of as little as 0.75 g a.e. ha^{-1} and 2,4-D spray tank contamination of 46 g a.e. ha^{-1} and higher can cause crop injury in non-resistant soybean when applied during vegetative or reproductive stages.

THE INFLUENCE OF CARRIER WATER HARDNESS ON 2,4-D CHOLINE EFFICACY. Pratap Devkota*, William G. Johnson; Purdue University, West Lafayette, IN (21)

Spray water quality is an important consideration for optimizing herbicide efficacy. The presence of hardness cations in the carrier water can influence herbicide performance. Greenhouse studies were conducted to evaluate the influence of hard water cations and water conditioning adjuvant on the efficacy of 2,4-D choline, a new low-volatility formulation of 2,4-D which will be applied on Enlist crops, for giant ragweed, horseweed, and Palmer amaranth control. Carrier water hardness was established at 0, 200, 400, 600, 800, or 1000 mg L^{-1} using calcium and magnesium cation in 3:1 ratio. Ammonium sulfate (AMS) was added either at 0% vv^{-1} (without) or 2.5% vv^{-1} (with) as water conditioning adjuvant. There was no interaction of carrier water hardness and AMS on 2,4-D choline efficacy except for giant ragweed control. Increased carrier water hardness showed a linear trend for reducing 2,4-D choline efficacy for giant ragweed, horseweed, and Palmer amaranth control. 2,4-D choline efficacy was reduced at least 20% with the increased carrier water hardness from 0 to 1000 mg L^{-1}. Use of AMS showed improved weed control with 2,4-D choline application. Over, the efficacy of 2,4-D choline was 17% or greater for giant ragweed, horseweed, and Palmer amaranth control with the addition of AMS. Therefore, carrier water hardness >200 mg L^{-1} has a potential to reduce the efficacy of the newer formulation of 2,4-D. Use of AMS as water conditioning adjuvant has a potential to improve herbicide efficacy when hardness cations are present in the carrier water.

ENLIST SOYBEAN WEED CONTROL OPTIONS FOR CONTROLLING 5 WAY RESISTANT WATERHEMP POPULATION IN ILLINOIS. David M. Simpson*[1], Kevin D. Johnson[2]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences, Danville, IL (22)

Waterhemp (*Amaranthus tuberculatus*) has developed single and multiple resistance to EPSPS, ALS and PPO inhibiting herbicides.   A waterhemp population in central Illinois was confirmed in 2015 to be resistant to HPPD, atrazine, ALS, PPO, and 2,4-D herbicides. Enlist™ soybean has tolerance to 2,4-D choline, glyphosate and glufosinate. Enlist Duo® herbicide with Colex-D Technology is a premix of 2,4-D choline and glyphosate registered for the use on Enlist soybean. GF-3335 is an experimental formulation of 2,4-D choline with Colex-D technology being developed for use on Enlist soybean.   In 2016, a field trial was conducted to evaluate various weed control programs enabled by Enlist soybean for control of the 5-way resistant waterhemp population. The first control program consisted of cloransulam + sulfentrazone applied pre-emergence followed by a single post-emergence application of glyphosate, Enlist Duo, GF-3335 + glufosinate, or glufosinate at 28 d after planting. Alternatively, a sequential post-emergence program consisting two applications of Enlist Duo, GF-3335, or GF-3335 + glufosinate and the sequential treatment of Enlist Duo + glyphosate followed by glufosinate applied at 21 and 35 d after planting was tested. The PRE followed by POST applications of either glyphosate or Enlist Duo provided >90% control of waterhemp 28 d after the POST application. The PRE followed by glufosinate treatments provided less than 60% control. This may have been due to size of waterhemp being too large at time of POST application and more timely applications of glufosinate is required. Tank mixing GF-3335 with glufosinate increased control to 78%. The control with two POST applications was greater than 92% with treatments. Interestingly, two POST applications of GF-3335 at 1065 g ae/ha provided 92% control of the 5-way resistant waterhemp. Enlist soybean enable multiple modes of actions to be utilized in a program approach to control herbicide resistant populations of waterhemp. Future research should look at options for a PRE followed by two POST applications that vary the multiple modes of actions in each POST application.

EMERGENCE PATTERN OF PALMER AMARANTH IN RESPONSE TO DIFFERENT RATES OF METRIBUZIN AND SULFENTRAZONE. Matheus de Avellar*, Liberty Butts, Greg R. Kruger, Rodrigo Werle; University of Nebraska-Lincoln, North Platte, NE (23)

Palmer amaranth (*Amaranthus palmeri*) has become a troublesome weed in row crop production across the U.S. It has an extended emergence pattern, which makes control difficult; moreover, several populations have evolved resistance to glyphosate and other herbicide modes-of-action. The use of soil-applied herbicides with residual activity is highly recommended for management of Palmer amaranth. The objective of this study was to evaluate the impact of different rates of soil-applied soybean herbicides used solely or in tank-mixture on the emergence pattern of Palmer amaranth. In 2016, the study was conducted near McCook, NE in a field infested with Palmer amaranth. Treatments consisted of metribuzin and sulfentrazone applied at their label rate, 560 and 280 g ai ha^{-1}, respectively, and also 2/3 and 1/3 of the label rates. Moreover, metribuzin and sulfentrazone were tank mixed with rates of both active ingredients varying from full, 2/3, and a 1/3 of the label rates. A control plot was also included, for a total of 16 treatments. Herbicide treatments were sprayed using a CO_2 backpack sprayer on 05/14/2016, three d after soybeans were planted. Plots were four rows wide (3 m) by 12.1 m long, replicated four times. The experiment was arranged in a randomized complete block design. Three quadrats (76 x 76 cm) were established in each plot between rows 1-2, 2-3 and 3-4. Starting after herbicide application, on a weekly basis, Palmer amaranth seedlings were counted and pulled from the quadrats. Total seedling emergence per quadrat and time to 50% emergence was estimated. Metribuzin and sulfentrazone reduced the total number of Palmer amaranth seedlings when compared to the control treatment; however, the reduction was herbicide and rate dependent. Low rates of metribuzin were not effective on Palmer amaranth control. The use of sulfentrazone resulted in satisfactory reduction of Palmer amaranth seedlings. Time to 50% cumulative emergence was not influenced by the treatments. For proper Palmer amaranth control, soil-applied herbicides should be applied at full label rate or in tank-mixture of multiple effective active ingredients. Moreover, fields should be constantly scouted for timely post-emergence applications. This study will be replicated in 2017 at multiple locations.

EFFECT OF SOIL HERBICIDES ON A PPO-SENSITIVE SOYBEAN UNDER WEED-FREE CONDITIONS. Rhett L. Stolte*[1], Ronald F. Krausz[2], Karla L. Gage[1]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (25)

A weed-free field study was established in Belleville, IL to evaluate the growth, development and yield of a protoporphyrinogen oxidase (PPO) inhibitor-sensitive soybean variety. The study consisted of 15 treatments with seven herbicide products at 1X and 2X rates with four replicates. Plot size was 3 m wide by 8 m long, owing for four 76-cm soybean rows. Soybeans were planted on May 9, 2016. Herbicides were applied to four rows and data were collected from the center two rows. Data collection included crop injury (height reduction) ratings at 21, 42, and 63 d after application (DAA), stand counts at 29 DAA and end-of-season (EOS), EOS plant heights, and grain yield. Herbicide treatments were: chlorimuron (33.6 g ai ha^{-1} and 67 g ai ha^{-1}), cloransulam (35.3 g ai ha^{-1} and 70.6 g ai ha^{-1}), sulfentrazone (280 g ai ha^{-1} and 560 g ai ha^{-1}), flumioxazin (72 g ai ha^{-1} and 143 g ai ha^{-1}), sulfentrazone + chlorimuron (314 g ai ha^{-1} and 630 g ai ha^{-1}), sulfentrazone + cloransulam (314 g ai ha^{-1} and 630 g ai ha^{-1}), and flumioxazin + chlorimuron (99 g ai ha^{-1} and 197 g ai ha^{-1}). Rainf for herbicide activation totaled 54 mm over five d after application with below normal minimum and maximum temperatures for 10 d (8.9 C and 21 C, respectively). Sulfentrazone at the 1X rate alone or in combination with chlorimuron or cloransulam caused 43 to 58% injury at 21 DAA. Injury caused by sulfentrazone alone or in combination with chlorimuron or cloransulam was persistent with injury ranging from 13 to 23% at 42 DAA and 10 to 18% at 63 DAA. Sulfentrazone alone or combined with chlorimuron at the 2X rate doubled crop injury compared to the 1X rate of sulfentrazone at 21, 42, and 63 DAA. Flumioxizin at the 1X rate alone or in combination with chlorimuron caused 15 to 18% injury at 21 DAA and the injury did not persist with only 0 to 3% injury observed at 42 and 63 DAA. Crop stand reduction mirrored the visual crop injury ratings especiy where injury was the greatest. Sulfentrazone alone at the 1X reduced crop stand by 50% at EOS whereas flumioxazin alone at the 1X rate reduced crop stand by 25% at EOS compared to the nontreated. Combinations of sulfentrazone plus chlorimuron or cloransulam and flumioxazin plus chlorimuron did not increase crop stand reduction compared to either herbicide alone. Sulfentrazone and flumioxazin at the 1X rate alone and combinations of sulfentrazone plus either chlorimuron or cloransulam and flumioxazin plus chlorimuron reduced soybean height at EOS. Yield reduction for most treatments was less than 10% (471 kg ha^{-1}) but sulfentrazone at the 1X rate alone reduced yield by 23% compared to the nontreated. Despite the injury caused by flumioxazin alone, flumioxazin did not reduce yield. Under abnormal weather conditions (cool and wet) immediately after planting, sulfentrazone caused more injury to a PPO inhibitor-sensitive soybean variety compared to flumioxazin. However the addition of chlorimuron or cloransulam to sulfentrazone did not increase injury compared to sulfentrazone alone.

MANAGING WATERHEMP IN SOYBEANS WITH LAYERED RESIDUAL HERBICIDES. A STRATEGY FOR CONTROLLING HERBICIDE RESISTANT WATERHEMP IN MINNESOTA. Lisa M. Behnken*[1], Fritz R. Breitenbach[2], Jeffrey L. Gunsolus[3], Phyllis M. Bongard[3]; [1]University of Minnesota, Rochester, MN, [2]University of Minnesota Extension, Rochester, MN, [3]University of Minnesota Extension, St. Paul, MN (26)

The objective of this trial was to evaluate and demonstrate the effectiveness of layering soil residual herbicides for control of waterhemp in soybeans in southeastern Minnesota. T waterhemp *(Amaranthus tuberculatus)* is becoming more widespread throughout Minnesota. Most waterhemp populations in Minnesota are resistant to ALS (Group 2) herbicides. In 2007, waterhemp populations resistant to glyphosate (Group 9) were reported and in 2015 and 2016, waterhemp populations in southern Minnesota were confirmed resistant to PPO herbicides (Group 14), with some populations resistant to both Group 9 and Group 14. New management strategies to control waterhemp are needed. One strategy for dealing with glyphosate-, PPO- and ALS-resistant waterhemp is to layer soil residual herbicides (Group 15), preemergence (PRE) followed by additional residual herbicide (Group 15) at early post-emergence (POST), about 30 d after planting. Waterhemp seedlings emerge over an extended period of time, frequently outlasting the effective residual control achieved by herbicides applied before or at crop planting. Several residual herbicides may be applied post-emergence to the crop alone or in combination with other post-emergent herbicides. When activated by rainf, these post-applied residual herbicides can extend the duration of waterhemp seedling control. Three herbicides were evaluated in this study in 2015 and 2016, 1) s-metolachlor at 1600 g ai ha^{-1} PRE only or 1600 g ai ha^{-1} PRE followed by 1070 g ai ha^{-1} POST, 2) dimethenamid-P at 940 g ai ha^{-1} PRE only or 736 g ai ha^{-1}PRE followed by 525 g ai ha^{-1} POST, and 3) acetochlor at 1350 g ai ha^{-1} PRE only or 1350 g ai ha^{-1} PRE followed by 1350 g ai ha^{-1}POST. These were selected because of their known effectiveness for controlling waterhemp and their flexibility of application timing. Rates used were based on soil type and seasonal limits. The waterhemp population at Rochester is ALS (Group 2) resistant. Imazethapyr in 2015 and chloransulam in 2016 were used preemergence to assist in controlling other broadleaf weeds present in this study. A randomized complete block design was used with three replications. Preemergence treatments were applied at planting on May 5, 2015 and May 4, 2016. Layered soil residual products were applied post-emergence, 34 d (2015) and 29 d (2016) after preemergence herbicides were applied. Evaluations of the plots were taken from May through September. Layered or sequential applications of Dual II Magnum, Outlook, or Warrant herbicide provided better, (95, 94, and 90%, respectively) season-long control of waterhemp compared to their PRE only treatments (81, 71, and 62%, respectively) at the September 29, 2015 rating. The results were similar in 2016 with Dual II Magnum, Outlook and Warrant providing ly better (94, 95 and 91%, respectively) season long control of waterhemp compared to their PRE only treatments (76, 79, and 79%, respectively) at the September 26, 2016 rating. The performance of these herbicides applied PRE correlates with their half-life, (average 30 d) as control starts to diminish about 30 d after application. This illustrates the need for additional weed management strategies to achieve season-long control of herbicide resistant waterhemp.

PALMER AMARANTH CONTROL IN DOUBLE CROP DICAMBA-GLYPHOSATE-RESISTANT SOYBEANS. Nathaniel R. Thompson*[1], Das E. Peterson[1], Gary L. Cramer[2], Chris M. Mayo[3], Cathy L. Minihan[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hutchinson, KS, [3]Monsanto, Gardner, KS (27)

No-till double crop soybean after wheat harvest is a popular cropping system in central and eastern Kansas; however, management of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) has become a serious issue in soybean. Geneticy modified soybean resistant to glyphosate and dicamba (Roundup Ready 2 Xtend) is a new technology that could help manage glyphosate resistant Palmer amaranth in double crop soybean. Therefore, field experiments were established in Manhattan and Hutchinson, KS, in 2016 to assess the objective of comparing 17 herbicide programs for control of Palmer amaranth and other weeds in dicamba-glyphosate-resistant no-till double crop soybean after wheat. Heavy Palmer amaranth populations were present at both locations before and after wheat harvest (greater than 50 plants m^2). Preplant treatments were applied at both locations five d following wheat harvest. Preplant treatments consisted of dicamba + glyphosate + residual, glyphosate + residual, glufosinate + residual, and paraquat + residual. POST treatments consisted of combinations of dicamba + glyphosate + acetochlor or glyphosate + lactofen and were made at 21 and 17 d after planting in Manhattan and Hutchinson, respectively, when Palmer amaranth was between 7.5 and 15 cm in height. Palmer amaranth populations at both locations were a mixture of both glyphosate-susceptible and resistant biotypes, but were predominantly susceptible at Manhattan and resistant at Hutchinson. Programs that contained a residual preplant herbicide followed by a POST treatment with multiple sites-of-action offered higher Palmer amaranth control eight wk after planting when compared to preplant only programs. Programs that consisted of preplant paraquat or glufosinate resulted in ly less control of large crabgrass when compared to preplant treatments that contained glyphosate. Soybean grain yield was higher in programs that contained a preplant treatment followed by POST treatment rather than in those that only had a preplant treatment. Geneticy modified soybean resistant to glyphosate and dicamba offers a new management strategy for controlling glyphosate-resistant Palmer amaranth in no-till double crop soybean after wheat when a program that consists of a preplant followed by a POST treatment is implemented.

RAINF IMPACTS THE RESIDUAL ACTIVITY OF DICAMBA ON MORNINGGLORY (*IPOMOEA SPP.)* AND COMMON WATERHEMP *(AMARANTHUS RUDIS)*. Andy J. Luke*, Reid Smeda; University of Missouri, Columbia, MO (28)

Dicamba is traditiony used as a post-emergence herbicide, but field observations suggest residual activity may also be exhibited. In a greenhouse setting, the influence of varying rates of dicamba and subsequent activating rainf on common waterhemp (*Amaranthus rudis*) and morningglory (*Ipomoea spp.*) emergence was measured. Polypropylene containers (67 by 40 cm) were filled with field soil; 20 cm diameter pieces of PVC were fitted four cm into the soil. Weed species were seeded individuy in rings and containers were treated with dicamba ranging from 0.14 to 1.12 kg ae ha^{-1} or 0.072 kg ae ha^{-1} flumioxazin. Simulated rainf ranging from zero to one cm was then applied to each container. To encourage continued emergence, soil outside the rings was watered daily. Weed emergence was recorded in each ring every three d. At 15 d after treatment (DAT), morningglory emergence was similar to the control for treatments receiving no rainf. For treatments receiving one cm rainf, emergence was reduced from 18 to 80% for dicamba rates ranging from 0.14 to 1.12 kg ha^{-1}. With low rainf (0.13 cm), only the highest rate of dicamba reduced morningglory emergence (37%). At 18 DAT, treatments with flumioxazin reduced waterhemp emergence up to 87 and 99% at rainf rates of 0.13 cm and one cm, respectively. Dicamba reduced waterhemp emergence from 41 to 84% as rates increased from 0.14 to 1.12 kg ha^{-1} following one cm of rainf. Without rainf, dicamba was only marginiy effective for reducing waterhemp emergence; 58% at 1.12 kg ha^{-1}. Across dicamba only treatments, reductions in waterhemp emergence were an average of 65% versus 47% at high compared to low rainf, respectively, suggesting dicamba activity is promoted by rainf. Dicamba exhibits residual activity in the soil for at least 18 d, and should be viewed as a supplement and not a substitute for use as a traditional residual herbicide such as flumioxazin.

ROUNDUP READY 2 XTEND SOYBEAN SYSTEMS. Scott A. Nolte*; Monsanto, St. Louis, MO (29)

Managing tough-to-control and herbicide-resistant weeds economicy, has been and continues to be a chenge that soybean growers are faced with. Successful integrated weed management systems require an understanding of crop and weed interactions. Weeds impact soybean yield potential by competing for limited light, water, and nutrient resources. Nearly complete weed control is needed during the first wk after soybean emergence to avoid potential yield losses due to early emerging weeds. Soybeans are especiy sensitive to moisture deficiencies in late summer and even a few large weeds left in the field can severely reduce yield potential. Roundup Ready 2 Xtend® Soybeans is the industry's first biotech-stacked soybean trait with both dicamba and glyphosate herbicide tolerance. Use of the Roundup Ready® Xtend Crop System can help maximize weed control and increase yield potential by enabling the use of multiple modes of action on soybean products built on the high yielding Genuity® Roundup Ready 2 Yield® Soybean technology. Field studies were conducted in 2016 at 10 locations across multiple states to evaluate weed control, grain yield and the economic return of three levels of herbicide input within the Roundup Ready® Xtend Crop System as compared with a competitor soybean system. Roundup Ready 2 Xtend® soybeans and LibertyLink® soybeans were planted on 30 inch rows in a conventional tillage system. The study was a split plot design with the main plot being trait and herbicide input being the subplot. Herbicide input levels were low, medium and high. The low input level included one soil residual herbicide applied preemergence (PRE), followed by (fb) a post-emergence (POST) application of Roundup Xtend™ with VaporGrip™ Technology (64 oz/ac) or Liberty® (29 oz/ac), as dictated by trait. Building on the low input level, the medium level contained an additional PRE herbicide for a total of two sites of action applied PRE. Building on the medium input level, the high level contained an additional residual herbicide in the POST application for overlapping residual activity. At harvest, regardless of herbicide input level, total weed control was 97% or greater in the Roundup Ready® Xtend Crop System, while in the LibertyLink® system weed control was 75.2, 84.6, & 87.0% at the low, medium and high input levels, respectively. Yield was also ly higher in the Roundup Ready® Xtend Crop System, regardless of herbicide input level, at 71.0-72.4 bu/ac, compared to the LibertyLink® system at 63.1-67.1 bu/ac. The Roundup Ready® Xtend Crop System also provided ly greater economic return at the low and high herbicide input levels of 543.7 and 533.8 $/ac, compared to the LibertyLink® system at 481.7 and 476.1 $/ac, respectively. Optimizing profitability and management of tough-to-control and herbicide-resistant weeds can be achieved by selecting a high yield potential soybean product matched to the appropriate weed control program, for weed species present in the field. The Roundup Ready® Xtend Crop System can provide consistent weed control, high yield and maximized profit, while using multiple modes of action and practicing good weed resistance management.

ROUNDUP READY[R] XTEND CROP SYSTEM: STEWARDSHIP IN PRACTICE. Sara M. en*[1], Susan E. Curvey[2], Michelle R. Starke[2], Boyd J. Carey[2]; [1]Monsanto, Bonnie, IL, [2]Monsanto, St. Louis, MO (30)

Monsanto has been working on the introduction of dicamba-tolerant crops for over ten years. The Roundup Ready Xtend Crop System will be one of the largest launches of a biotechnology and crop protection system in history. In the last several years, Monsanto has preparing for the launch by building education and stewardship plans that included customer centric educational opportunities, internal education and confidence building in a new system and collaboration with industry partners. The tactics utilized innovative ideas about education, collaboration and the use of technology to promote education and stewardship for the system. The over planning and tactics used demonstrate flexibility and agility to implement over the time that Monsanto has been preparing for the launch.

TIMING OF HERBICIDE APPLICATIONS AND/OR TILLAGE AFFECTS CONTROL OF GLYPHOSATE-RESISTANT HORSEWEED IN SOYBEAN. Parminder S. Chahal*[1], Amit Jhala[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska Lincoln, Lincoln, NE (31)

The widespread adoption of reduced tillage practices and heavy reliance on single modes-of-action herbicides in the past few decades has resulted in the evolution of herbicide-resistant (HR) weeds in the U.S., including glyphosate-resistant (GR) horseweed. A field experiment was conducted in 2015 and 2016 in a field infested with GR horseweed in Lincoln, Nebraska. The objective of the experiment was to compare the efficacy of f or spring tillage or herbicide burndown programs (2,4-d ester and carfentrazone ethyl tank-mixture) applied alone or in combination with PRE (sulfentrazone plus metribuzin) or POST herbicide applications (fomesafen and cloransulam tank-mixture) for the management of GR horseweed in soybean. The f burndown and tillage applications provided similar level of horseweed control (≥90%) until the spring burndown and tillage applications. At four WA spring applications, spring tillage and burndown as well as f tillage provided similar GR horseweed control (>80%); however, f burndown controlled horseweed <70%. At two WAPRE, tillage and burndown applications applied alone, except f burndown (53%), or when *fb* PRE herbicide controlled GR horseweed >75%. At six WAPOST, f and spring tillage or burndown applications *fb* POST only or PRE *fb* POST controlled GR horseweed >85%. Horseweed plant density was reduced by >85% with f and spring tillage or burndown applications *fb* PRE, POST or both as well as with f and spring tillage applied alone at six WAPOST. Contrast analysis suggested that a horseweed management program included with tillage applications provided greater control (≥85) and plant density reduction (≥95%) compared to herbicide burndown applications (<85%), respectively, throughout the season. Similar horseweed biomass reduction was observed for treatments. Both tillage and burndown applications *fb* POST only or PRE *fb* POST provided similar and highest soybean yield (1094 to 1454 kg ha^{-1}). Therefore, integrated weed management programs including tillage and different sites-of-action PRE residuals and POST herbicides need to be followed for effective management of GR horseweed without imposing further herbicide selection pressure.

SCHEDULED HERBICIDE APPLICATIONS AND MICRO-RATES: IS THERE A FIT IN HERBICIDE-RESISTANT SOYBEAN? Mark L. Bernards*, Brent S. Heaton; Western Illinois University, Macomb, IL (32)

Micro-rate herbicide programs were developed for sugarbeets (*Beta vulgaris*) in the 1990's to 1) reduce crop response to labeled herbicides, 2) improve weed control by targeting smer weeds, and 3) reduce herbicide expenses. Micro-rate herbicide applications were based on a calendar-day interval (7 -10 d) or growing degree day accumulation (GDD) or sugarbeet growth stage. The intent of frequent applications was to target weeds when they were at the cotyledon or first leaf stages. Micro-rate herbicide programs could begin with a preemergence herbicide application followed by multiple POST applications, or could include only POST applications. Soybean (*Glycine max*) growers with glyphosate-resistant weeds have turned to herbicides that are more phytotoxic than glyphosate and less effective at controlling large weeds. A standard recommendation is also to apply "full-labeled rates" of herbicides and to apply multiple effective herbicide mechanisms-of-action for each key weed in a field. This has resulted in a increase in the herbicide volume applied to many fields, and seems counter to the ecological ideal of minimizing pesticide use. The objective of this study was to evaluate weed control and soybean yield response to scheduled herbicide applications with micro-rates and standard use rates. Soybean (Asgrow 3334 RR2Y) were planted in 76-cm rows at 395,000 seeds ha^{-1} on 20 May 2016 on the Western Illinois University Agricultural Field Laboratory in Macomb, IL. The herbicides used were pre-mixtures of fomesafen (114 g L^{-1}) + S-metolachlor (520 g L^{-1}) and glyphosate (540 g ae L^{-1}). The control applications were 1) no herbicide, 2) single application at VC (fomesafen, 266 g ha^{-1}, + S-metolachlor, 1214 g ha^{-1}, + glyphosate, 1260 g ae ha^{-1}), and 3) single application of glyphosate (1260 g ae ha^{-1}) 35 d after VC. The first herbicide application (A) was made 31 May to VC soybean. Subsequent applications (depending on treatment) were made either 28 DAA, or 35 DAA, or 14 and 28 DAA, or 10, 20 and 30 DAA. (An intended 21 DAA was missed, and treatments scheduled for 21 DAA were applied 35 DAA). Three rate structures of tank-mixtures of fomesafen + s-metolachlor + glyphosate were applied at each of the application times. At 28 and 35 DAA a single application of glyphosate followed a full dose of the residual herbicide as standard treatments. Weeds present (and approximate densities) in the study area included *Setaria faberi* (50 plants m^{-2}), *Amaranthus tuberculatus* (20 plants m^{-2}), *Xanthium strumarium* (4 plants m^{-2}), *Ipomoea hederacea* (1 plant m^{-2}), *Abutilon theophrasti* (1 plant m^{-2}), and *Chenopodium album* (1 plant m^{-2}). weeds in the study area were susceptible to glyphosate. Weed control at two wk after the final application, averaged across species, was 94-97% for treatments except the single application at VC, which was 71%. The soybean canopy closed after this rating. A preharvest rating was similar: weed control averaged across species was greater than 96% for treatments except the single application at VC, which was 61%. Soybean yield pareled weed control ratings. Yield of the untreated check was 1939 kg ha^{-1}, yield of the single herbicide application at VC was 3772 kg ha^{-1}, and yield of the remainder of the treatments ranged from 4522 to 5412 kg ha^{-1}. The combined dosage of herbicides for the three-pass (VC, 14 and 28 DAA) and four-pass (VC, 10, 20 and 30 DAA) treatments was less than the full labeled dose applied in the VC followed by 28 DAA treatment. Although application costs have not been factored into the analysis above, we believe these results support further exploration of the concept of scheduled weed control with reduced rates. Future research should include a greater diversity of herbicides (and herbicide mechanisms-of-action), and be conducted in fields with glyphosate-resistant weeds.

DETERMINING AT-HARVEST SEED RETENTION OF 3 PROBLEMATIC WEED SPECIES IN SOYBEAN. Drake J. Gleeson*[1], Eric G. Oseland[1], Meghan Biggs[1], Mandy D. Bish[2], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (33)

The continued increase of weed species with multiple herbicide resistances combined with a lack of new herbicide sites-of-action has resulted in a need to integrate more non-chemical measures for control of resistant weeds. Harvest Weed Seed Control (HWSC) is one technique that has been successfully adopted in Australia for management of problematic weed species, but more research is needed to understand the adaptability of this method to Midwest U.S. agriculture. For HWSC to be effective it is essential that the majority of seed is retained by the weed at harvest. This research was conducted to determine the seed retention of three problematic weed species in soybean. Giant foxtail (*Setaria faberi*), common waterhemp (*Amaranthus tuberculatus*), and giant ragweed (*Ambrosia trifida*) have each been shown to impact soybean yield and are common species throughout most of the Midwest. The seed retention of the three species was determined by comparing the amount of weed seed retained on the plant at soybean maturity to the amount of weed seed shattered. In May of 2016, a 0.2 hectare area was planted to soybean with 72-cm row spacing. At time of planting, giant ragweed seedlings were transplanted between soybean rows at a minimum of two m spacing between plants. Giant foxtail and waterhemp seed were spread in two-meter increments between soybean rows, and later thinned to one plant per two meters of soybean row. As weed seedheads began to form, four collection trays (51 x 40 x 6 cm) were lined with landscape fabric and pinned to the soil at the base of 16 target plants of each species. Seed from each tray was collected once per week. Seed collection and counts continued for five wk following soybean maturity at which time each individual plant was harvested, weighed, and threshed for the remainder of seed. Soybean reached maturity on September 26 however seed from giant foxtail plants were collected in trays as early as August 19th. Giant ragweed and waterhemp seed began to shatter into their respective collection trays one week prior to soybean maturity. Preliminary results of the giant ragweed data indicate 98.9% of the seed was retained on plants the week of September 19th, and 89.9% of seed was retained one week later at the time soybean matured. One week following soybean maturity, 69.9% of giant ragweed seed was left intact on the plants. By wk three to five following soybean maturity, giant ragweed seed retention averaged 38.6 to 35.2%. Two rainf events occurred within relevant dates that may have influenced seed drop. During the first week following soybean maturity 6.35 cm of rain was recorded in a 3-hour timeframe. In the third week following maturity, 14.48 cm of rain was recorded within 22 hr. This ongoing research is part of a larger U.S. Dept. of Agriculture-Agricultural Research Service (USDA-ARS) Area wide project focused on managing herbicide resistance. Results from this study will provide insight as to the compatibility of HWSC as a non-chemical weed control option for use in Midwest soybean production.

EFFICACY OF HALAUXIFEN-METHYL HERBICIDE PROGRAMS FOR MANAGEMENT OF GLYPHOSATE-RESISTANT HORSEWEED (*CONYZA CANADENSIS* L.) IN SOYBEAN. Marcelo Zimmer*[1], Bryan Young[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (34)

Glyphosate-resistant (GR) horseweed is a major concern for no-till soybean production throughout the Midwest, U.S. Preplant applications of synthetic auxins have been effectively used to control GR horseweed. Halauxifen-methyl is a new synthetic auxin active ingredient, which is highly effective for controlling horseweed at low use rates (5 g ae ha^{-1}). Thus, field research was conducted at three locations in 2015 and 2016 to evaluate the efficacy of herbicide programs utilizing halauxifen-methyl in comparison with other existing herbicide programs. Data collection consisted of visual estimates of weed control and crop injury, weed density counts, soybean stand counts, and soybean grain yield. Herbicide treatments that included halauxifen-methyl provided visual control of GR horseweed ranging from 87 to 96% at 35 d after treatment (DAT) when data for site-years were combined. The efficacy of burndown treatments using either glyphosate, glufosinate, or 2,4-D alone varied considerably across site-years. Average visual horseweed control was 33% for glyphosate, 59% for glufosinate, and 72% for 2,4-D at 35 DAT with data for site-years combined. A contrast was performed to compare the efficacy of herbicide programs using halauxifen-methyl against other existing herbicide programs. This comparison was with p-value <0.0001 with an estimated increase of 15% control of GR horseweed. Horseweed density counts at 35 DAT did not correspond to the visual control data due to the long period of time required between application of synthetic auxin herbicides and complete plant death. Crop injury up to 10% was observed for treatments using dicamba or chlorimuron-ethyl; however, it did not impact soybean yield. The non-treated check and glyphosate alone treatments resulted in lower soybean yield than other herbicide treatments. In summary, halauxifen-methyl may be a valuable addition for management of GR horseweed prior to soybean planting relative to common herbicide programs.

WATERHEMP CONTROL IN EDIBLE LIMA BEAN PRODUCTION IN SE MINNESOTA. Fritz R. Breitenbach*[1], Lisa M. Behnken[2]; [1]University of Minnesota Extension, Rochester, MN, [2]University of Minnesota, Rochester, MN (35)

Effective broadleaf weed control especiy *Amaranthus spp.* (*A. tuberculatus* and *A. rudis*), has become chenging in many broadleaf crops in MN. In the lima bean production areas in SE Minnesota, *Amaranthus* resistance is documented for ALS-inhibiting herbicides (Group 2), glycine herbicides (Group 9), and recently (2016) PPO-inhibiting herbicides (Group 14). Multi-herbicide-resistant *Amaranthus* has become widespread across Minnesota and has complicated weed control efforts. Pendimethalin tank mixtures with imazethapyr are currently utilized on the majority of southeastern Minnesota lima bean production acres. Inadequate *Amaranthus* control with this program has resulted in fewer acres in production and reduced grower profits. In 2016 a trial was conducted in edible lima beans to evaluate both labeled and un-labeled herbicides. Labeled products included bentazon (POST), imazamox (POST), imazethapyr, (PPI), pendimethalin (PPI), and s-metolachlor (PPI & PRE). Herbicides without current lima bean labels included fomesafen (PRE & POST), sulfentrazone (PRE), and POST applied s-metolachlor. Weed control, crop response, and plump pod weight were collected as measures of performance in this trial. Minor differences in *Amaranthus* control were observed in the study. Over control of *Amaranthus* was very good to excellent. Crop response to both PRE applied and POST applied herbicides treatments was observed and appeared to be the largest contributor to decreased plump pod weight other than zero weed control.

EXAMINING COMMERCIAL SEED MIXTURES FOR THE PRESENCE OF WEED SPECIES. Eric G. Oseland*, Meghan Biggs, Mandy Bish, Kevin W. Bradley; University of Missouri, Columbia, MO (36)

Palmer amaranth (*Amaranthus palmeri*) is one of the most economicy important weed species in the U.S. The weed is native to the southern U.S. but has expanded its distribution into more northern geographies in recent years. Some of this recent movement has been attributed to contaminated machinery, livestock feed, and waterfowl dispersal. New infestations of Palmer amaranth were also discovered in Illinois, Iowa, and Ohio in 2016 and the source of these plants were traced back to commercial seed mixtures used for conservation reserve program (CRP) areas and/or pollinator plantings. The goal of this research was to determine if commerciy available bird seed, pollinator seed mixtures, CRP seed mixtures, and wildlife food plot mixtures contain weed seed and if so, to identify the weed species present, their abundance, and viability. Twelve sources of bird seed from nine different companies, seven sources of wildlife food plot seed mixtures from six companies, five sources of pollinator seed mixtures from five companies, and four sources of CRP seed mixtures from two companies were examined for the presence of weed seed. seed mixtures were sorted through a series of sieves and visuy examined for the presence of weed seed. Each individual weed seed was removed, counted, identified by species, and stored for future viability testing. Preliminary results have shown that *Amaranthus* species were present in 12 bags of bird seed examined. The smest amount detected was six pigweed seed per kilogram of birdseed mix for one source while the most was 2,404 pigweed seed per kilogram of birdseed mix in another source. Common ragweed (*Ambrosia artemisiifolia* L.), shattercane [*Sorghum bicolor* (L.) Moench ssp. *arundinaceium* (Desy) de Wet & Harlan], wild buckwheat (*Polygonum convolvulus* L.) large crabgrass (*Digitaria sanguinalis*) and *Setaria* spp. were also among the weed species present in the birdseed mixtures. The largest amount of grass seed detected to date has been 178 seed per kilogram of birdseed. *Amaranthus* species seed has also been discovered in at least one wildlife food plot mix. Additional assessments are being conducted on weed seed in the CRP and pollinator mixes. Results from this study will provide information about the potential involvement of commercial seed mixtures to spread economicy important weed seeds throughout the U.S. Future work will include identifying which species of *Amaranthus*, *Setaria*, and any other unknown weeds are present in these seed mixes, and determining the viability of weed seeds identified.

EFFICACY OF AIM, LIBERTY AND COBRA APPLIED THROUGH TWIN FAN NOZZLES. Annah Geyer*[1], Ronald Navarrete[2], Juan Espinoza[2], Spencer L. Samuelson[1], Jeffrey A. Golus[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Zamorano University, Tegucigalpa, Honduras (37)

Contact herbicides genery provide greater efficacy when paired with nozzles producing a smer droplet size spectrum. This is due to the smer droplet size distribution providing greater leaf coverage. A study was conducted to evaluate eight nozzles and three herbicides when applied to flax, oat, velvetleaf, lambsquarter, and kochia. Nozzles used were the TH60-11003, TTJ60-11003, AI3070 11003, GAT11003, TADF11003, AITTJ60-11003, XR11003, and the AIXR11003 at 32 psi herbicides used were Aim at 0.5 oz ac^{-1} with 0.25%v v^{-1} NIS, Liberty at 14.5 oz ac^{-1} with 0.25%v v^{-1} NIS, and Cobra at 6.25 oz ac^{-1} with 0.25%v/v NIS. In general, the TTJ and the TJ nozzles provided the greatest efficacy at 28 d after treatment.

INFLUENCE OF NOZZLE SPACING, BOOM HEIGHT AND NOZZLE TYPE ON THE EFFICACY OF GLUFOSINATE, DICAMBA, GLYPHOSATE AND SAFLUFENACIL. Lucas Giorgianni Campos*, Kasey Schroeder, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (38)

One of the largest chenges in agriculture is weed management. Good weed control is highly correlated with the product and the application method. Application technology is a science that is focused on improving herbicide efficiency and weed management. The objective of this research was to determine which combinations of nozzle spacing, boom height, and nozzle type are most efficacious with glufosinate, dicamba, glyphosate, and saflufenacil when applied on common lambsquarters (*Chenopodium album L.*), velvetleaf (*Abutilon theophrasti Medik.*), grain sorghum (*Sorghum bicolor L.*), and Palmer amaranth (*Amaranthus palmeri S. Wats.*). The study was conducted in a greenhouse. Applications were made when plants were 10 – 15 cm in height. The experiment was a completely randomized factorial design (four nozzle types x three boom heights x three nozzles spacing x four herbicides x four weed species) replicated in space and time. Nozzle spacing of 38, 50, and 76 cm were used in a 1.67 x 4.2 m spray chamber with a single track with a three nozzle boom. Herbicides were applied at 2.75 bar, and the application rate was 94 l ha^{-1} (glyphosate, saflufenacil, and dicamba) and 140 l ha^{-1} (glufosinate). Herbicides were applied at 473 g ae ha^{-1} glyphosate, 286 g ai ha^{-1} glufosinate, 140 g ae ha^{-1} dicamba, and 37 g ai ha^{-1} saflufenacil. Applications were made using four nozzles: Extended Range flat fan spray tip (XR11004), Air Induction XR flat fan spray tips (AIXR11004), Turbo Teejet wide angle flat fan spray tips (TT11004) and Turbo Teejet Induction flat fan spray tips (TTI11004). Boom heights tested were 30.5, 45.7, and 61.0 cm. Visual estimations of weed control were taken at 7, 14, 21, and 28 d after application (DAA). At 28 DAA, plants were harvested, dried to a constant mass, and dry weighs were recorded. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test using a Tukey adjustment. Results showed interactions between nozzle type, nozzle spacing, and boom height above the target for each herbicide solution within each weed species. These data suggest that we need to adjust our application techniques for different situations in order to promote greater weed efficacy.

INFLUENCE OF SPRAY VOLUME AND DROPLET SIZE ON THE CONTROL OF PALMER AMARANTH (*AMARANTHUS PALMERI*) AND HORSEWEED (*CONYZA CANADENSIS*). Henrique Campos*, Bruno Canella Vieira, Thomas R. Butts, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (39)

Maximizing herbicide efficacy for herbicide applications occurs in the early growth stages of weeds. The rapid development of weeds chenges timely herbicide applications and growers often look for ways to increase efficiency, including the use of low spray volumes to increase the area covered in a single tank load. In this study, we evaluated the influence of carrier volume and droplet size on the control of Palmer amaranth and horseweed. The treatments consisted of two nozzles (TXA 8001 and TT 11001 at 248 kPa) and three spray volumes (19, 37 and 75 l ha^{-1} by using the speeds of 14, 7 and 3,5 km h^{-1}, respectively) and. These two nozzles produce a fine and medium spray quality, respectively. Dicamba (Clarity®) was used at a rate of 280 g ae ha^{-1}. Plants were sprayed in a three nozzle track sprayer, and at 21 d after application (DAA), plants were harvested and dry weights were recorded. Dry weight data were analyzed in SAS (PROC GLIMMIX), and when appropriate, means were separated by Fisher LSD test. When contrasting TXA and TT nozzles, Palmer amaranth dry weight was 62.5% lower in TT nozzles than TXA nozzles, independently of the spray volumes. In regard to horseweed, the rate of control was the greatest at 75 l ha^{-1}, regardless of nozzle type.

INFLUENCE OF STRIKELOCK ON HERBICIDE PERFORMANCE. Laura Hennemann*; Winfield United, River Fs, WI (40)

The performance of certain herbicides is increased with the use of oil based adjuvants. These hydrophilic herbicides are used alone or in a tank-mixture situation with glyphosate. However, oil adjuvants have a proven track record of antagonism when used with glyphosate. Methylated Seed Oil High Surfactant Oil Concentrates (MSO-HSOC) are a newer generation of oil adjuvants. MSO-HSOC (Destiny® HC and Superb® HC) have shown excellent compatibility with glyphosate while still providing similar performance when tank-mixed with herbicides that require an oil based adjuvant system. StrikeLock™ is a new, novel MSO-HSOC adjuvant that provides weed efficacy comparable to other MSO-HSOC adjuvants as well as having drift and deposition properties. When evaluated on drift performance, StrikeLock™ showed a decrease in fine droplets comparable to other commercial drift reduction adjuvants. In field trials, StrikeLock™ provided similar to better weed efficacy when compared to similar MSO-HSOC adjuvants.

INFLUENCE OF NOZZLE TYPE AND PRESSURE ON DROPLET SIZE FROM ROUNDUP POWERMAX, CLARITY, AND ROUNDUP POWERMAX AND CLARITY TANK-MIXTURES. André de Oliveira Rodrigues*[1], Kasey Schroeder[2], Jeffrey A. Golus[2], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (41)

Droplet size is important to the quality of application especiy with the increase in the number of drift cases which is a major concern in agricultural production systems globy. Droplet size is modified by several application parameters, such as the nozzle selection, application pressure, and spray solution. This study evaluated the influence of nozzle type and application pressure combined with commonly sprayed herbicides on droplet size distributions. The study was conducted with two herbicides, Roundup PowerMax (glyphosate) 0.77 kg $aeha^{-1}$ and Clarity (dicamba) 0.56 kg $aeha^{-1}$, tested alone and in tank-mixtures. The application rate was 94 l ha^{-1} and the pressures used were 124, 207, 276, 345, 482, and 517 kPa. These pressures were combined with the appropriate orifice size to produce the correct carrier volume. Three commonly used nozzles were selected for this study, XR, AIXR, and TTI nozzles. A wide range of orifice sizes were used to maintain a constant application rate ranging from 110015 to 11006. The study was conducted at the Pesticide Application Technology Laboratory at UNL-WCREC in North Platte NE, using a low speed wind tunnel and droplet measurements were made using a Sympatec HELOS-VARIO/KR laser diffraction system. Each nozzle was traversed through the laser beam three separate times to measure the entire spray plume providing three repetitions. The nozzle was located 30 cm from the laser beam. Data were subjected ANOVA and means were separated using Fisher's Protected LSD test with the Tukey adjustment. After analysis of the Volume Median Diameter (VMD) from the three types of nozzles, we concluded that the TTI generated the largest droplet size, followed by the AIXR and the XR nozzles, respectively. When comparing solutions, it was observed in general that Clarity generated the largest droplet size, followed by Roundup PowerMax and the tank-mixture, respectively.

LABORATORY METHODS FOR DETERMINING VOLATILITY POTENTIAL OF HERBICIDES. David G. Ouse*, James M. Gifford; Dow AgroSciences, Indianapolis, IN (42)

A method was developed to quantify volatility of 2,4-D and dicamba acids. Compressed air, an air pressure regulator, a pressure relief valve and air flow gauges (Dwyer Instruments Inc. Hwy 210 E, Fergus Fs, MN 56537, Model No. RMB-53D-SSV) were used to deliver uniform air flow through polycarbonate aquariums that contained treated plants. Aquariums dimensions measure 24.5 cm wide by 38.5 cm long by 49.5 cm t for a total volume of 0.047 m^3. Air sampling tubes (SKC Inc. 863 Vey View Road Eighty Four, PA 15330, Catalog No. Xad-2 OVS) were inserted through a hole in the lid of the aquarium and connected to a vacuum line. A rubber stopper with a hole for the vacuum line was fitted into the lid to seal the inlet hole for the sampling tube. Each sampling tube was calibrated using an adjustable low flow tube holder (SKC Catalog No. 224-26-01) to set air flow to 1 liter $minute^{-1}$. An airflow rate of 20 l $minute^{-1}$ through each aquarium eliminated issues of condensation inside the aquarium, sampling tubes and vacuum lines. Several aquariums were placed in a growth chamber where temperature was controlled. This method allows for comparison of treatments without the concern of cross-contamination since airflow into the aquariums is supplied from a remotely located air compressor. The 2,4-D acid or dicamba acid in the vapor phase was captured in the SKC sampling tubes. Tubes were changed every 24 hr for four d and frozen after collection. Sampling tubes were later extracted with 10 ml of methanol for two hr. During the extraction process of the internal contents of the tubes were expelled into a glass vial with disposable wooden dowels. Quantification of 2,4-D acid or dicamba acid was determined using LC / MS-MS with sensitivity limit of 5 ppb. Data are presented as a percent of herbicide applied by calculating the amount of herbicide applied to the surface area treated. Using this method the cumulative volatility over four d of 2,4-D choline was determined to be about 10-fold lower than the volatility of 2,4-D dimethylammonium. This method has provided repeatable results with standard deviation of $\leq$ 0.15 % of herbicide applied. Previous volatility research using humidomes owed comparison between formulations using injury on sensitive crops as a bio-indicator of volatility. This method allows for the quantification of volatility over time and a means to compare formulations with quantative data.

WHICH FACTOR INFLUENCES DICAMBA VOLATILITY THE GREATEST: SOIL, FOLIAGE OR ADJUVANT? Jamie L. Long*, Bryan Young; Purdue University, West Lafayette, IN (43)

The commercialization of dicamba-tolerant soybean will lead to more prevalent dicamba applications and highlight the importance of proper stewardship in performing herbicide applications. Spray application factors, such as the use of adjuvants, may influence the amount of dicamba volatility in the field and previous research documented greater amounts of volatility may occur on plant surfaces compared to bare soil surfaces. Therefore, a field experiment was conducted over three site years in Lafayette, IN to determine dicamba vapor movement as influenced by target surface of the sprayed area and the addition of different herbicide adjuvants. Greenhouse flats with bare soil or with an established vegetative canopy from a corn/soybean mixture represented two spray target surfaces (soil vs. vegetation). Dicamba (dimethylamine salt) was applied at 1.1 kg ha^{-1} to promote higher levels of vapor evolution to improve the detection of differences between treatments. Four herbicide treatments included a no dicamba control, dicamba alone (no adjuvant), dicamba plus methylated seed oil (MSO; 1% v v^{-1}), and dicamba plus an oil emulsion drift control agent (280 ml ha^{-1}). Field plots were six m wide by 15 m long which owed for eight soybean rows with a 76-cm spacing. In the center of each plot a 4.6 m by 2.4 m open-ended low tunnel covered with plastic was placed over the center two rows. treatments were applied to the greenhouse flats at a remote location to prevent any spray particle drift to the experimental plots. Within five minutes of the herbicide application, the flats were transported to assigned field plots and placed under the center of the plastic tunnels between the two soybean rows. Each tunnel contained two greenhouse flats, to serve as a source for dicamba vapor, and remained in the tunnel for 48 hr. Visual estimates of soybean injury within the soybean rows were recorded using a scale adapted from Behrens and Lueschen (1979) in 0.5-m increments from the center of the plastic tunnel to the end of the plots 3, 7, 14, 21, and 28 d after treatment (DAT). At 28 DAT soybean plant height and node counts were collected. At 14 and 28 DAT soybean injury from dicamba applied to a bare soil surface was 5 to 12% on plants immediately adjacent to the dicamba vapor source. Soybean injury from dicamba applied to flats with corn/soybean vegetation was 20 to 26%. The addition of an adjuvant did not influence the amount of soybean injury due to dicamba vapor from either target surface. As has been previously published, this research reconfirms that volatility from a soil surface was less than that from a vegetative surface. This research also determined that the adjuvants tested, under these environmental conditions, did not influence dicamba volatility. Preliminary greenhouse research suggests that environmental factors, particularly air temperature, may influence the amount of dicamba volatility from the addition of adjuvants applied with dicamba to foliage; therefore, controlled environment experiments will be conducted to determine this effect.

SIMULATED TANK CONTAMINATION OF 2,4-D WITH COMBINATIONS OF DICAMBA AND GLYPHOSATE APPLIED TO DICAMBA TOLERANT SOYBEANS. Brent C. Mansfield*, Marcelo L. Moretti, Bryan Young; Purdue University, West Lafayette, IN (44)

Soybeans varieties with resistance traits for dicamba and 2,4-D are expected to gain adoption by U.S. farmers over the next few years. The adoption of these new technologies also brings concerns and risks of off-target herbicide movement through spray particle drift and/or tank contamination. The mechanism of resistance for both traits is rapid metabolism of 2,4-D and dicamba to prevent any substantial phytotoxic activity in soybean. However, the potential exists for 2,4-D to be a tank contaminant in an application of a labeled rate of dicamba to dicamba-resistant soybean. The ensuing application may result in some interaction of these herbicides on the TIR1 auxin receptors and develop a soybean response unlike that observed for soybeans without the dicamba trait such as glyphosate-resistant soybean. Therefore, the objective of this research was to characterize the response of dicamba and glyphosate-resistant soybeans (Roundup Ready Xtend) and glyphosate-resistant soybean (Roundup Ready 2 Yield) to both 2,4-D and dicamba applications as potential tank contaminants on plant development and productivity. The experiments were conducted at the Throckmorton Purdue Agricultural Center near Lafayette, IN in 2016. The experimental design was a factorial with two herbicides, two soybean growth stages, and five herbicide rates with four replications. The two soybean growth stages were evaluated to compare treatment effect on vegetative growth (V2) versus reproductive growth (R1). The effective herbicide doses causing 5%, 10% and 20% yield loss were calculated. The dicamba-resistant soybeans were affected by 2,4-D applied as a tank contaminant. However, the addition of dicamba at a full labeled rate did not affect soybean response to 2,4-D. The extent of soybean injury was dependent on growth stage, but only at the 14 DAT evaluations. Plant injury and height reduction at 28 DAT or most plant components or yield components were not dependent on soybean growth stage at the time of exposure to 2,4-D. The estimated 2,4-D rate to cause 5, 10 and 20% yield loss were 26, 51, and 130 g ae ha^{-1}, which are 5, 9 and 23%, respectively, of a normal 560 g ha^{-1} rate of 2,4-D. In the glyphosate-resistant soybean experiment, soybean injury parameters were ly affected by the herbicide used and rate, but the soybean growth stage was not a factor in most evaluations. Dicamba provided a greater reduction of plant height and yield as compared to 2,4-D. Based on the data, dicamba-resistant soybean exposure to 2,4-D rates as low as 5% of field rate have the potential to cause 5% yield loss at both growth stages tested. In conclusion, 2,4-D did not interact with the full rate of dicamba on dicamba-resistant soybean.

SPRAYER CLINICS: ADDING TO THE AGRONOMY TOOLBOX. David J. Palecek*; Winfield United, River Fs, WI (45)

Herbicide mixtures perform best when they are properly mixed and applied using best practices. Winfield United has been conducting many training opportunities to field staff, retail dealers, commercial applicators and producers to provide them the information, equipment and methods to apply herbicides safely, effectively and with minimal risk. Multiple times a year, Winfield United hosts sprayer clinics. This educational opportunity takes place in the field with a group of selected individuals. Winfield United sales and marketing staff, as well as key growers, are treated to a day of spray application specific topics. The goal is to help these individuals better understand the many factors that influence an application's effectiveness. The intent is to help applicators make better informed decisions when choosing a program for a particular grower or field situation. The program begins with a walk around demonstration of our John Deere R4023 self-propelled sprayer. Being able to have a commercial sprayer on site day is vital to the over success of the training. Various systems and components on the machine are identified and discussed. Pulse Width Modulation, (PWM) is explained and demonstrated. The participants in training perform a full boom spray calibration, and wrap up with a large group sprayer clean out exercise. After the large group session, participants rotate through several sm group concurrent sessions. These concurrent sessions cover nozzle selection, rate and boom control, and lastly an individual "ride and drive" session. This session allows people to actuy get behind the controls of a commercial sprayer, and simulate an actual field application. This showcases the precision agriculture features on the machine, and rey gives the attendee a chance to feel what it's like to spray a field. At the end of the day, participants are brought back together for a general session for question and answers and reinforcement of the day's learnings. Sprayer Clinics are an important way that Winfield United is stewarding good application management for the benefit of the industry and producers alike.

CHANGE IN DROPLET SIZE FROM PLUGGED AIR INDUCTION PORTS ON VENTURI NOZZLES. Débora de Oliveira Latorre*[1], Thomas R. Butts[1], Jesaelen G. Moraes[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (46)

Venturi nozzles have been used for herbicide applications to reduce the risk of spray particle drift. The objective of our research was to evaluate the droplet size distribution of five venturi nozzles before and after plugging air inclusion ports. The study was conducted as a completely randomized factorial design using the low-speed wind tunnel at the Pesticide Application Technology Lab at the West Central Research and Extension Center in North Platte, NE, using a Sympatec HELOS- ARIO/KR laser diffraction system for droplet measurements. Water was sprayed through five venturi nozzles each with two orifice sizes: an Air Induction flat fan spray tip (AI11004 and AI11006), Air Induction XR flat fan spray tip (AIXR11004 and AIXR11006), Turbo Induction flat fan spray tip (TTI11004 and TTI11006), Turbo Drop XL tip (TDXL11004 and TDXL11006), and Ultra Lo-drift nozzle (ULD12004 and ULD12006). Each nozzle was tested with air inclusion ports open, one port plugged, or two ports plugged, other than the TTI nozzles which were tested as either open or plugged. Applications were made at 276 kPa with three replicates. The volumetric droplet size spectra parameters used for data interpretation were DV_{10}, DV_{50}, DV_{90}, droplets < 150 µm, and relative span (RS). The RS was determined by subtracting the DV_{10} value from the DV_{90} value and dividing by the DV_{50}. Data were subjected to ANOVA using the PROC GLIMMIX procedure in SAS v 9.4 and means were separated at $\alpha = 0.05$ using Fisher's protected LSD test and the Tukey adjustment. A nozzle*plugged port*orifice size interaction was for the DV_{10}, DV_{50}, DV_{90}, and RS ($p<0.0001$); however a similar pattern emerged across orifice sizes. Performance was different with TTI, AI, and TDXL nozzles compared to ULD and AIXR nozzles. When one port in TTI nozzle was plugged, the DV_{50} increased by 6.5%, and 4.3%, for the 04 and 06 orifice sizes, respectively. Whereas AI and TDXL nozzles had a decrease in DV_{50} value of 15.0 and 13.9% for the 04 orifice sizes, and 13.5 and 12.6% for the orifice 06, respectively, when two ports were plugged. The nozzles TDXL and AI for the orifice 04 produced more percentage droplets ≤ 150 µm with two ports plugged, while AIXR produced more with air inclusion ports open plugged. In summary, the volumetric droplet size spectra parameters in plugged ports in venture nozzle may performs differently for nozzle type.

HOW WELL DO FARMERS CURRENT PRACTICES FIT WITH UPCOMING HERBICIDE RESISTANT CROP TECHNOLOGIES? Lizabeth Stahl*[1], Lisa M. Behnken[2], Fritz R. Breitenbach[3], Ryan P. Miller[4], David Nicolai[5]; [1]University of MN Extension, Worthington, MN, [2]University of Minnesota, Rochester, MN, [3]University of Minnesota Extension, Rochester, MN, [4]University of MN Extension, Rochester, MN, [5]University of MN Extension, Farmington, MN (47)

Upcoming herbicide-resistant crop technologies will offer growers an expanded range of tools in weed control, particularly in the control of glyphosate-resistant weeds. At least several of these tools are expected to come with specific requirements to help reduce drift and to prevent injury to sensitive crops and vegetation. Requirements to date include, but are not limited to, the use of drift-reducing nozzles and specific tank cleaning procedures. Use of preemergence/residual herbicides is also being promoted as an integral part of these systems. Efforts have been made to educate growers and agricultural professionals about these application requirements in anticipation of regulatory approval and product launch. To help target educational efforts, it is important to understand how farmers' current practices compare to suggested or required practices with these systems. Data collected at University of Minnesota Private Pesticide Applicator Training sessions through paper surveys (since 2003) and use of Turning Technologies' Response Cards (since 2008), provide a snap shot of farmers' practices. Since first asked in 2008, respondents have reported flat fan nozzles are the nozzle type they most widely use. Most recently in 2016, 50% of the respondents reported they primarily used flat fan nozzles. This would not meet the standards of upcoming growth regulator, herbicide-resistant technologies, which require the use of specific drift-reducing nozzles. Although the percentage of respondents who switch nozzle type based on pesticide label requirements increased from 29% in 2014 to 43% in 2016, the majority still report using the same nozzle season (55% in 2016). Since 2003, an increasing number of growers reported using water and a tank-cleaner when switching from one crop to a susceptible crop (from 44% in 2003 to 68% in 2016), but the percentage of respondents that reported checking the herbicide label for instructions on how to clean the tank has never exceeded 28% (e.g. in 2016 only 19% reported doing so). Less than half the respondents (43, 45, and 41% in 2014, 2015, and 2016, respectively) reported rinsing the tank at least three times when switching to a sensitive crop. A percentage of farmers reported using a preemergence/residual herbicide on of their acres in corn (61 and 64% in 2015 and 2016, respectively) and soybean (59 and 61% in 2015 and 2016, respectively). However, 23 to 25% of the respondents in 2015 and 2016 indicated they did not use one on any of their corn or soybean acres. This information has been useful in helping identify educational and outreach needs to help increase the potential for successful use of these systems by farmers who choose to use them.

DIGITAL BOOKS FOR WEED IDENTIFICATION. Bruce A. Ackley*; The Ohio State University, Columbus, OH (48)

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

APPLICATION TIMING OF PPO-INHIBITOR HERBICIDES INFLUENCES LEVEL OF PALMER AMARANTH CONTROL. Larry J. Rains*[1], Das Peterson[2]; [1]Kansas State Weed Science Dept., Manhattan, KS, [2]Kansas State University, Manhattan, KS (49)

Application timing is critical for good control of Palmer amaranth (AMAPA) with post-emergence PPO-inhibiting herbicides, but rapid growth rates of AMAPA increases difficulty of timely applications and effective control. Therefore, it is important to select the best herbicide program based on weed height and number of d after emergence. A field experiment was conducted in 2016 at the Department of Agronomy Ashland Bottoms Research Farm near Manhattan, KS, to evaluate application timing of PPO-inhibitingherbicides for AMAPA control. The test was configured in a split block design, consisting of seven treatment timings as the main plot and three herbicide treatments as the subplots. The experiment had four replications and included an untreated check for comparison. Treatments were applied every three for 21 d starting when average height of AMAPA reached 2.5 cm. Acifluorfen, fomesafen, and lactofen were applied at 426 g ai ha^{-1}, 280 g ai ha^{-1}, and 224 g ai ha^{-1}, respectively. herbicide treatments were applied in 140 l ha $^{-1}$ spray solution in combination with methylated seed oil at 1.17 l ha^{-1} and ammonium sulfate at 2.34 l ha^{-1}. Palmer amaranth control was evaluated visuy at one and two week intervals after each herbicide application. In addition, height measurements were recorded every three d. When lactofen was applied six d after initial applications, AMAPA control reduced to an unacceptable level (70%), however, acifluorfen and fomesafen still provided acceptable control (>95%). treatments applied 12 d after the initial application resulted in 65% control or less. Average AMAPA size on day 12 was 30 cm t, corresponding with a growth rate of 2.5 cm per d. As plants neared the 21 d application timing, growth rates increased. Due to the fast growth rates of AMAPA, early application timings are required for adequate control. Future experiments will include more narrow application intervals, to better understand the optimal intervals and AMAPA sizes to achieve acceptable herbicide efficacy.

HERBICIDE-RESISTANT COMMON WATERHEMP AND PALMER AMARANTH IN WISCONSIN. Devin J. Hammer*, Nathan M. Drewitz, David E. Stoltenberg, Shawn P. Conley; University of Wisconsin-Madison, Madison, WI (50)

The spread of common waterhemp (*Amaranthus rudis*) and Palmer amaranth (*Amaranthus palmeri*) has become an increasing concern in Wisconsin. Both species are renowned for their competitive ability, abundant seed production, and propensity for developing herbicide resistance. Acetolactate synthase (ALS) inhibitor-resistant common waterhemp was first confirmed in Wisconsin in 1999. No additional instances of herbicide-resistant common waterhemp occurred in Wisconsin until 2013 when glyphosate-resistant common waterhemp was confirmed in two west-central counties. Also in 2013, the first occurrence of Palmer amaranth was documented in Wisconsin. This population was subsequently confirmed to be resistant to glyphosate. Since that time, Palmer amaranth has been found in three additional counties in Wisconsin. Responding to continued widespread concerns among growers of possible herbicide-resistant common waterhemp and Palmer amaranth, we collected seeds from six common waterhemp populations from Chippewa, Outagamie, Sheboygan, and Waupaca counties in 2014, and five populations from Crawford, Lafayette, and Walworth counties in 2015. Once common waterhemp seed samples were dried and cleaned, seeds were stratified for six wk. For Palmer amaranth, seeds were collected from populations from Iowa and Grant counties in 2014 and 2015, respectively. Palmer amaranth seeds were stored at -20 C. Dose-response experiments were conducted at the University of Wisconsin Walnut Street Greenhouse facility to confirm and quantify herbicide resistance. Separate experiments were conducted for each herbicide and species. The experimental design was a randomized complete block with six to 10 replications. The experimental unit was one plant. Experiments were repeated in time or space. Common waterhemp and Palmer amaranth seeds were plated on petri dishes, germinated, and transplanted to soil-less potting mix. Plants were grown to heights recommended for herbicide treatment. For common waterhemp, glyphosate was applied to putative-resistant (R) and sensitive (S) populations at eight rates ranging from 0 to 13.9 kg ae ha^{-1}. Palmer amaranth populations were tested for resistance to glyphosate, imazethapyr, thifensulfuron, and tembotrione. For suspected ALS-inhibitor resistance in Palmer amaranth, imazethapyr was applied to R and S plants at six rates ranging from 0 to 7.0 kg ai ha^{-1}; thifensulfuron was applied at seven rates ranging from 0 to 0.044 kg ai ha^{-1}. For suspected HPPD-inhibitor resistance, tembotrione was applied at seven rates ranging from 0 to 0.9 kg ai ha^{-1}. Glyphosate was applied as described above. Shoot dry biomass was collected 28 d after treatment, dried, and weighed. Comparisons between a known S population and suspected R populations were made based on the herbicide dose required to reduce weed shoot biomass by 50% (ED_{50}). Dose-response results confirmed glyphosate resistance in common waterhemp populations from Chippewa, Crawford, Lafayette, Outagamie, Sheboygan, Walworth, and Waupaca counties. Furthermore, results from the University of Illinois Plant Clinic confirmed glyphosate resistance in waterhemp populations from seven more counties and PPO-inhibitor resistance in a population from Monroe County making it the first confirmed case of multiple resistance to these two herbicide sites-of-action in Wisconsin. The Iowa County Palmer amaranth population displayed a greater than 150-fold level of resistance to imazethapyr and a low-level (4.9-fold) of resistance to thifensulfuron. Although the Iowa County Palmer amaranth population was found to be sensitive to glyphosate, it demonstrated a 7.0-fold resistance to tembotrione, confirming the first case of multiple herbicide resistance in Wisconsin Palmer amaranth. The Palmer amaranth population from Grant County was sensitive to herbicides sites-of-action tested. Our findings indicate that the distribution of common waterhemp and the occurrence of glyphosate resistance (including a multiple resistance to PPO-inhibitors) have increased rapidly in Wisconsin. Although the distribution of Palmer amaranth appears to be limited to four counties in southern and southwestern Wisconsin, the confirmation of glyphosate resistance in two populations, and multiple resistance to ALS- and HPPD-inhibitors in another population, have serious management implications for Wisconsin growers. It is critical that diverse resistance management strategies be implemented to reduce the spread, persistence, and impact of these and other herbicide-resistant species.

WEED CONTROL PROGRAMS WITH DICAMBA AND RESIDUALS IN DICAMBA TOLERANT SOYBEANS. Jon E. Scott*, Stevan Knezevic; University of Nebraska-Lincoln, Concord, NE (51)

Weed resistance is on the increase, therefore, introduction of dicamba-tolerant soybeans could provide another option for weed control. Four studies were conducted in 2016 including three no-till and one conventional-till. One of the no-till studies was conducted in a non-crop setting while the other three studies were taken to yield and the subsequent crop destroyed due to pending herbicide label status. The focus of the studies was to evaluate several soil residual herbicides and dicamba timing for weed control efficacy. In conventional-till, sulfentrazone based herbicide products provided excellent preemergence weed control and post-emergence dicamba with or without a soil residual product aided in problem weeds such as venice mow to provide a complete weed control program. In no-till, soil residuals were applied early preplant with glyphosate alone or with 2,4-D or dicamba. Dicamba aided in winter annual burndown, especiy in the case of henbit and marestail. Post-emergence applied dicamba did provide complete control of glyphosate-resistant marestail. Combination herbicides containing flumioxazin, pyroxasulfone, saflufenacil, or sulfentrazone did aid in early season weed control, however post-emergence treatments were needed for green foxtail, velvetleaf and waterhemp depending on the herbicide component. Again, post-emergence dicamba did aid in complete weed control. No soybean phytotoxicity was observed and yields were protected vs. the nontreated check in these studies. These results indicated potential use of dicamba to control various weed species; however repeated use of dicamba alone or in combination with glyphosate should be avoided to reduce probabilities for dicamba resistance, as there is already dicamba-resistant kochia in western Nebraska, eastern Colorado and eastern Wyoming.

SOYBEAN RESPONSE TO CURRENT HERBICIDES. Crystal Dau*, Anita Dille; Kansas State University, Manhattan, KS (52)

Controlling problem weeds has been a constant chenge in farmers' minds. As companies within the agronomic industry recognize the importance of managing these chenges, they have continued releasing product lines that offer control through encouraging use of different modes-of-actions. In the field, there is a strong need for education about herbicides and the corresponding seed trait technologies before the industry can safely and effectively utilize these tools as they become available. Recognizing this need for education, we decided to test these technologies and portray the importance of good stewardship with combining the right seed traits with the proper herbicides. The objectives for this research were to compare the responses of the various soybean platforms to the right and wrong herbicide applications and to create education materials to be shared with farmers and applicators who will be using these technologies. The experimental approach was to compare five seed trait technologies against five different herbicide treatments. The soybean see traits were conventional, RoundUp Ready, RoundUp Ready 2 Yield, LibertyLink, and a dicamba-tolerant variety. Two plants were established in each pot. The herbicide treatments were water alone, water with AMS (1.13 kilograms ac^{-1}), glufosinate (1.06 liters ac^{-1}) and AMS (1.13 kilograms ac^{-1}), glyphosate (0.95 liters ac^{-1}) and AMS (1.13 kilograms ac^{-1}), and dicamba (0.95 liters ac^{-1}) and (AMS 1.13 kilograms ac-1). The soybean plants were treated once the first trifoliate was fully developed. After 28 d, we took pictures of the soybeans to compare symptoms. Results showed that injury symptoms appeared within one week. The results from this research will provide valuable information to help soybean farmers to avoid losses in their operations by realizing the critical need to match herbicide applications with correct seed trait technology.

BURNDOWN OF GLYPHOSATE-RESISTANT MARESTAIL IN NORTHEAST NEBRASKA. Jon E. Scott*, Stevan Knezevic; University of Nebraska-Lincoln, Concord, NE (53)

Due to the rolling topography in northeast Nebraska, adoption of no-till practices are now common. This has caused a weed shift towards winter annuals, of which horseweed *(Conyza canadensis* (L.) Cronq. (= *Erigeron* c. L.)) is prevalent in many no till fields. Initial control measures consisted primarily of glyphosate applied either before planting (as a burndown) or early post-emergence in soybean. This glyphosate use pattern has led to an increase glyphosate-resistant horseweed. The first line of defense was to add 2,4-D as a burndown application, which had 7 to 14 day preplant interval in corn and a 7 to 30 day preplant interval in soybean, however due to cooler temperatures at application, the horseweed control was not acceptable. Therefore, a research site at the University of Nebraska – Lincoln Haskell Agriculture Laboratory in Concord, NE was established where horseweed population contained 2-4X glyphosate resistance levels. Experimentation with glufosinate or gramoxone applied alone did not provide acceptable horseweed control. Addition of residual herbicides to glyphosate and 2,4-D did increase control of horseweed in both corn and soybean before crop planting. Addition of dicamba to glyphosate, or to various tank-mixtures containing residual herbicides, also improved horseweed control to the acceptable levels in corn. The use of a dicamba-tolerant soybean also provided treatments that completely controlled glyphosate resistant horseweed. This suggests that herbicide programs containing several modes-of-action are needed to combat horseweed resistance. Programs with multiple modes-of-actions would also help avoid further weed resistance issues.

AN AIRTRACTOR 502 SIMULATOR FOR TRAINING AGRICULTURAL AVIATION PILOTS ON PESTICIDE APPLICATIONS. Jeffrey A. Golus*, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (54)

Many products are applied aeriy to control fungal diseases, insect infestations, weeds, and other pests. While many aerial applicators are professional with a strong desire to carry out their profession in a sustainable and efficacious way, there is little room for error and very few opportunities to practice application situations which they may encounter. To help in part with this training, an AirTractor 502 flight simulator was constructed at the University of Nebraska-Lincoln's Pesticide Application Technology Laboratory. The simulator is capable of replicating application environments using a 235 degree wrap around screen, giving the pilot trainee an "out the window" visualization. The system uses multiple projectors and a sound system to create a realistic learning experience. A trainer can induce differing scenarios during a flight including inducing emergency situations. This will ow the pilot to experience potentiy dangerous situations in an environment where there is no risk or liability, and the trainer can also evaluate reactions and provide feedback on management of the application process under the different scenarios. The methods and application techniques used during the application can also be evaluated and critiqued. The simulator will also provide valuable flight time for those in training to become pilots. Training courses will become available to increase pilot efficiency and also increase the accuracy and effectiveness of pesticide applications.

SIMULATED DRIFT OF DICAMBA ON POTENTIY SENSITIVE CROPS. Stevan Knezevic*, Maxwel C. Oliveira, Jon E. Scott; University of Nebraska-Lincoln, Concord, NE (55)

There is a concern that the widespread use of dicamba-based herbicides in dicamba-tolerant soybeans (Roundup-Ready 2 Xtend) can result in unintended drift due to windy conditions in Nebraska (and elsewhere). Therefore, the objective of this preliminary study was to establish some baseline indicators on the injury of potentiy sensitive crops (eg. non-dicamba-tolerant soybeans, grapes and tomato) to various micro rates of dicamba. Preliminary field study was conducted in 2016 as a split-plot design with four dicamba rates, two application times and four replications. Dicamba rates were: 0, 1/10, 1/100, 1/500 of the label rate of commonly known dicamba herbicide (560 g ae ha^{-1}). Plots had four rows of each soybean type (conventional, organic, glyphosate-resistant, glufosinate-resistant), and dicamba-tolerant soybeans (as a check) as well as pot-grown grape plants (2nd year of growth) and tomato seedlings. There were two application times of dicamba (eg. V2 (soybean 2nd trifoliate) and R2 (full flower) and corresponding size of grapes and tomato. Preliminary results suggested that four types of non-dicamba-tolerant soybeans were very sensitive to dicamba micro-rates (eg. simulated drift). For example, based on visual ratings, injuries ranged from 70-100% by the 1/10 and 20-60% by 1/100 as well as 20-50% by 1/500 rates applied at V2 stage. The 1/10 rate killed sm grapes and severely injured tomato (80%), while there were only temporary injuries with other dicamba rates, and the 2nd timing in grapes and tomato. Yield losses in non-dicamba-tolerant soybean due to injuries ranged from 10-90%. Yield losses were almost twice as high when dicamba was applied at R2 compared to V2 stage. For example, yield losses in organic soybeans sprayed with 1/10 rate were 50% and 85% at V2 and R2 stages, respectively. Also, yield losses in glufosinate-tolerant soybeans sprayed with 1/10 rate were 45% and 91% at V2 and R2 stages, respectively. Similar trend occurred in other non-dicamba-tolerant soybeans. This study will be repeated in 2017.

MOBILE LAB FOR TRAINING PESTICIDE APPLICATORS. Chandra J. Hawley*, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (56)

The University of Nebraska-Lincoln West Central Research and Extension Center in North Platte, Nebraska has established a large effort in pesticide application research dating back to the 1970's. In recent years, a large effort was put into establishing the Pesticide Application Technology (PAT) Lab, equipped with a state-of-the-art greenhouse and wind tunnels for collecting droplet size measurements as well as conducting field drift studies. With increasing pressure to reduce drift, pesticide use, and resistance while increasing the sustainability and efficacy of crop production systems, there is a need to have leading edge training for applicators. The Mobile Lab has traveled across the U.S. to provide educational opportunities for pesticide applicators. The 8 m Mobile Lab trailer houses a miniature wind tunnel to demonstrate how sm droplets move off-target and how drift reduction techniques such as nozzle selection as well as pressure and orifice size can influence particle size. It also contains a spray table equipped with lighting, pulse width modulation and other current technologies to demonstrate spray pattern distribution, calibration, nozzle selection and the potential influence of adjuvants. It may be reserved for full-day and partial day workshops, field day training, and one-on-one training at farm shows. The outcomes of these trainings are better prepared applicators and managers that can select the most appropriate application practices and techniques to reduce drift and maximize pesticide efficacy. For more information, visit pat.unl.edu.

ALTERNATIVES TO GLYPHOSATE FOR CHEMICAL WEED CONTROL IN WHEAT STUBBLE. Das E. Peterson*, Curtis R. Thompson, Cathy L. Minihan; Kansas State University, Manhattan, KS (57)

Glyphosate plus 2,4-D and/or dicamba was a standard treatment for weed control in wheat stubble in the Great Plains region for many years. It was assumed that the 2,4-D and dicamba components were making a contribution to broadleaf weed control, but with the evolution of glyphosate-resistant weeds, especiy Palmer amaranth and kochia, the treatment is no longer providing the desired level of weed control. Field experiments were established near Manhattan and Tribune, Kansas in 2015 and 2016 to evaluate herbicide alternatives to glyphosate for kochia and Palmer amaranth control in wheat stubble. Experiments in Tribune targeted kochia control and included post-emergence herbicide applications in the growing wheat as well as postharvest applications after wheat harvest in the wheat stubble. The experiment in Manhattan only included postharvest herbicide treatments in wheat stubble for Palmer amaranth control. The two most effective postharvest treatments for control of both kochia and Palmer amaranth included paraquat at 0.84 kg ha^{-1} or saflufenacil at 0.05 kg ha^{-1}, which provided 90 to 100% control of both species. Dicamba plus 2,4-D treatments provided good suppression of kochia and Palmer amaranth but were inconsistent and often some plants survived and produced viable seed. Suppression of kochia by a robust wheat crop or post-emergence herbicides in wheat that provide foliar and residual control of kochia may also be beneficial for efficacy of subsequent post-harvest herbicide treatments.

LIQUID PHYSICAL PROPERTIES AND DROPLET SIZE IN CLETHODIM APPLICATIONS. Marcella Guerreiro de Jesus*[1], Jesaelen G. Moraes[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (58)

Herbicide application efficiency many times hinges on coverage of the target pest which is influenced by numerous factors, among these include contact angle (CA) and surface tension (ST). The surface wettability may change depending on the CA as the solid and liquid interfaces interact. A sm CA results in high wettability, while large CA results in low wettability. The objective of our research was to evaluate the result of CA and ST in different superficies and spray solution. Measurements were made at the Pesticide Application Technology Laboratory (PAT Lab) located at the West Central Research and Extension Center in North Platte, NE using an optical tensiometer, OCA 15EC (DataPhysics Instruments GmbH, Filderstadt, Germany). The study was conducted as a completely randomized factorial design with four solutions: clethodim (SelectMax) alone at a low and high rate 0.0126 kg a.i ha^{-1} and 0.0336 kg a.i ha^{-1}, low rate of clethodim plus dicamba (Clarity)(0.0126 kg a.i ha^{-1} + 0.28 kg a.i ha^{-1}), and high rate of clethodim plus dicamba (0.0336 kg a.i ha^{-1} + 0.28 kg a.i ha^{-1}). Solutions contained NIS at 0.25% vv^{-1}). Three different droplet sizes, (500, 1000, and 1500 µm), were also measured on two contact surfaces (Mylar card and corn leaf) which resulted in a total of 24 treatments. Ten subsample measurements per treatment were recorded for CA, and each treatment was replicated three times. The ST, expressed as mNm^{-1}, was determined following the pendant drop-method (drop hanging on a needle), with three replications per treatment. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD test with the Tukey adjustment. The addition of dicamba to the tank solution caused an increase in surface tension. From the analysis, a solution*droplet size*contact surface interaction was observed ($P < 0.0001$) for both CA and ST. This was an unexpected result as previous literature does not mention differences in CA as droplet size changes; however, when working with sm drops, in the case of this work, we found this to be an important variable influencing CA. More research is needed to explain the variation of CA and ST from smer droplets.

DIVERSE HOMOEOLOG COMPOSITION IN OHEXAPLOID WILD OAT AS EVIDENCED BY PLASTIDIC ACCASE GENE SEQUENCES. Michael J. Christoffers*, Robert P. Sabba; North Dakota State University, Fargo, ND (59)

Wild oat (*Avena fatua* L.) is an ohexaploid (AACCDD) with three identified *Acc1* genes for plastidic acetyl-CoA carboxylase (ACCase), the target of ACCase-inhibiting herbicides. These independently assorting genes are considered homoeologous and have been designated *Acc1;1*, *Acc1;2*, and *Acc1;3*. A Cys2088Arg herbicide-resistance mutation was previously identified in the *Acc1;1* gene of VIR35 wild oat (ele *Acc1;1-5*) (GenBank HQ244403). We expanded the sequenced portion of *Acc1;1-5* and analyzed other *Acc1* homoeologs in VIR35 by cloning and sequencing polymerase chain reaction products amplified from genomic DNA. For each homoeolog, the sequenced region extended from the Ile1736 codon to 156 or 159 bp past the stop codon and included an intron. Analysis confirmed the Cys2088Arg mutation and revealed no other DNA sequence differences between *Acc1;1-5* and the *Acc1;1* gene of herbicide-susceptible KYN119 wild oat (ele *Acc1;1-7*) (GenBank KU363802). Among other *Acc1* sequences from VIR35 was a gene identical to the *Acc1;3* homoeolog of KYN119 (GenBank KU363804). While discovery of *Acc1;1* and *Acc1;3* homoeologs was as expected, no sequence clearly corresponding to *Acc1;2* was found. Rather, a sequence temporarily designated *Acc1;X1* was identified and found to be similar to the *Acc1;1* gene of USDA96 wild oat (ele *Acc1;1-1*) (GenBank AF231335 includes some but not of sequence analyzed here). It is not likely that *Acc1;X1* and *Acc1;1-5* are eles of the same *Acc1;1* gene, and features of *Acc1;X1* include Gly2153 due to G instead of A in the second position of the codon. The GenBank database includes some wild oat *Acc1* sequences with G/A ambiguities at this position, suggesting that *Acc1;X1* may not be unusual. Discovery of *Acc1;X1* in wild oat lacking a clear *Acc1;2* gene indicates diverse homoeolog composition and may suggest multiple polyploidization in the evolution of wild oat. The effects of such diversity on expression and evolution of herbicide resistance should be further examined, especiy among wild oat carrying the same target-site mutation but differing in homoeolog composition.

ADJUVANT INFLUENCE ON EFFICACY OF LACTOFEN. Rodger Farr*, Kasey Schroeder, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (60)

Many companies advertise the benefits of using chemical adjuvants spray mixtures for a multitude of reasons, including reduced drift or foaming and conditioning the water in the solution. Some producers have reported suspicion that these adjuvants can increase the effectiveness and damage caused by some herbicides. The objective of this study was to look at the effects of different adjuvants in conjunction with lactofen on three species: tomato (*Solanum lycopersicum*), soybean (*Glycine max (L) Merr.),* and cotton (*Gossypium hirsutum L.*). The plants were grown in a climate-controlled greenhouse and were treated three wk after planting. The three species were treated with 11 different solutions (lactofen, lactofen + water conditioner + drift control agent (I) + anti-transparent concentrate, lactofen + water conditioner + drift control agent/NIS + anti-transparent concentrate, lactofen + water conditioner + drift control agent (II) + crop oil, lactofen + water conditioner, lactofen + drift control agent (I), lactofen + anti-transparent concentrate, lactofen + drift control agent/NIS, lactofen + crop oil, lactofen + drift control agent (II), lactofen + water conditioner + crop oil) and two different nozzles (TTI11006 and XR11006) for a total of 22 different treatments using and a three nozzle laboratory tracksprayer. Treatments were chosen based on commonly used tank-mixtures in the field. Visual estimations of injury were collected at 7, 14, 21 and 28 DAT and then harvested and dried to determine the effects of the treatments at 28 DAT. The results of the study showed that the use of different nozzles (TTI11006 or XR11006) caused negligible difference in damage caused by the tank-mixtures. There was a difference in the damage caused by the treatments with adjuvants compared to the treatments using just lactofen. There was a difference in the degree of damage done to each species as well a variation as to which adjuvants caused more damage to each of the three species. For the soybeans, it was the lactofen + crop oil + water conditioner. For the cotton, it was the lactofen + drift control agent/NIS. For the tomatoes it was the lactofen+water conditioner + drift control agent (II) + crop oil. Caution should be used in selecting the most appropriate adjuvants for an application. If the use of adjuvants in conjunction with herbicides that are labeled for certain crops can cause increased injury to that crop, then these combinations could result in yield loss at the end of the year.

CONTROL OF GLYPHOSATE-RESISTANT HORSEWEED (*CONYZA CANADENSIS*) WITH HALAUXIFEN-METHYL VERSUS DICAMBA AND 2,4-D. Cara L. McCauley*, Bryan Young; Purdue University, West Lafayette, IN (61)

Since the discovery of glyphosate-resistant (GR) horseweed (*Conyza canadensis*) in 2001, management of this problematic broadleaf weed species in soybean has been a chenge. The auxin herbicides 2,4-D and dicamba are common components of chemical management strategies and halauxifen-methyl is a new auxin herbicide that is currently under development for use in a preplant burndown application to control GR horseweed. In 2015 and 2016, a field experiment was conducted at two field sites to investigate the response of GR horseweed populations to 2,4-D, dicamba, and halauxifen-methyl. Herbicide applications included halauxifen-methyl (2.5, 5, 10 g ae ha^{-1}), dicamba (140, 280, and 560 g ae ha^{-1}), and 2,4-D (280, 560, and 1120 g ae ha^{-1}) which represents an approximate 1/2X, 1X, and 2X of the field use rate for each of the herbicides. In addition, glyphosate at a rate of 870 g ae ha^{-1} was tank-mixed with each of the auxin herbicides at the 1X rate to evaluate any difference in the level of herbicide efficacy even though the two populations were glyphosate resistant. Visual estimates of control and inflorescent plant density were recorded following herbicide application. The efficacy of halauxifen-methyl and dicamba was similar at each respective herbicide rate, with 80% control at 28 d after treatment for the 1X rates when applied to GR horseweed up to 30 cm in height. Conversely, 2,4-D applications resulted in markedly less efficacy with less than 50% control of GR horseweed. Inflorescent plant density was reduced by 93% and 80% for the 1X dicamba and halauxifen-methyl treatments, respectively, while a 44% reduction was observed for the 1X

2,4-D treatment compared to nontreated plots. The addition of glyphosate to the 1X rate of dicamba and halauxifen-methyl had no effect compared to the 1X rate of the auxin herbicide applied alone. However, adding glyphosate to the 1X rate of 2,4-D increased control by 28%. The addition of glyphosate to any of the auxin herbicides had no effect on inflorescent plant density at the end of the season. These results suggest that halauxifen-methyl has the potential to be used for preplant management of GR horseweed. Due to the nature of auxin herbicides, in plots where treatments resulted in visual control up to 85%, plants still had the potential to produce seed at the end of the season.

COEVOLUTION OF RESISTANCE TO PPO INHIBITORS IN PALMER AMARANTH AND WATERHEMP. Kathryn J. Lillie*[1], Darci Giacomini[1], James R. Martin[2], JD Green[3], Patrick Tranel[1]; [1]University of Illinois, Urbana, IL, [2]University of Kentucky, Princeton, KY, [3]University of Kentucky, Lexington, KY (62)

Protoporphyrinogen oxidase (PPO) inhibitors have been used for over 50 years to control weeds in agronomic crops. Waterhemp (*Amaranthus tuberculatus*) evolved resistance to PPO-inhibiting herbicides in 2000, and was the first weed to do so. The mechanism for this resistance involves the loss of a glycine at position 210 in the mitochondrial isoform of the PPO enzyme (encoded by the *PPX2L* gene). Subsequently, the same mutation was identified in PPO-inhibitor-resistant Palmer amaranth (*A. palmeri*) from Arkansas and elsewhere. Within a single field in Kentucky, both waterhemp and Palmer amaranth were observed to be resistant to PPO inhibitors. Therefore research was conducted to determine the mechanism of resistance in each species, and to determine if resistance was transferred between the two species. A qPCR (Taqman) assay was run on plants collected from the field and revealed the presence of the ΔG210 deletion in *PPX2L* from both species. In order to confirm that there was no introgression between the two species, the *PPX2L* gene from both species was sequenced. Two distinct versions of this gene were found in both species, indicating that PPO resistance in these populations evolved separately. The waterhemp and Palmer amaranth populations with resistance to PPO-inhibiting herbicides occurring within a single field is a remarkable example of two species using the same evolutionary solution to overcome an abiotic stress.

A COMPARATIVE ANALYSIS OF THE PALMER AMARANTH AND WATERHEMP TRANSCRIPTOMES. Darci A. Giacomini*[1], Anita Kuepper[2], Todd A. Gaines[2], Roland Beffa[3], Patrick Tranel[1]; [1]University of Illinois, Urbana, IL, [2]Colorado State University, Fort Collins, CO, [3]Bayer CropScience, Frankfurt, Germany (63)

Despite the increasingly low costs of producing high quality, next generation sequence data, many common weed species are still lacking a fully sequenced transcriptome. Twenty weed species currently have a transcriptome assembly publicly available, but of the top ten weed species with the most independently evolved cases of herbicide resistance (based on number of herbicide sites-of-action), only five have transcriptome data. Here we present transcriptomic datasets for two weed species, one of which has never been published (*Amaranthus palmeri*) and another with a 400-fold increase in the amount of data compared to the previous assembly (*Amaranthus tuberculatus*). To generate as complete a picture of the expressed genes as possible, tissue was collected separately from floral tissue, and whole seedlings (including roots), and from plants after exposure to various herbicides. Six Illumina TruSeq Stranded RNAseq libraries were prepared for each tissue type by species combination and then sequenced using the Illumina HiSeq2500 platform. Both datasets each gave a final output of ~190 million, 250nt paired-end reads, which were assembled and annotated using Trinity and Trinotate pipeline, respectively. Between-species comparisons and between-tissue comparisons shed light on some defining characteristics of these two important weeds; highlighted here is a detailed look at the cytochrome P450 and glutathione-S-transferase gene families. It is our hope that these annotated, comprehensive transcriptome datasets will provide the weed science community with a rich resource for future work with *Amaranthus* species.

FIRST CASE OF GLYPHOSATE RESISTANCE IN PALMER AMARANTH (*AMARANTHUS PALMERI*) FROM MEXICO. Javid Gherekhloo[1], Pablo T. Fernandez-Moreno*[2], Jose A. Dominguez-Valenzuela[3], Hugo E. Cruz-Hipolito[4], Reid Smeda[5], Rafael A. De Prado[2]; [1]Department of Agronomy, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran, Gorgan, Iran, [2]University of Cordoba, Cordoba, Spain, [3]Department of Agricultural Parasitology, Chapingo Autonomous University, Road México, Texcoco Km. 38.5, 56230 Texcoco, México, Texcoco, Mexico, [4]Bayer CropScience, Col. Ampl. Granada 11520, México D.F, México D.F, Mexico, [5]University of Missouri, Columbia, MO (64)

Following introduction of glyphosate-resistant cotton in Mexico, farmers have relied upon glyphosate as the only herbicide for in-season weed control. Continuous use of glyphosate within the same year and over multiple years has resulted in the selection of glyphosate resistance in *Amaranthus palmeri*. Dose-response assays confirmed resistance among seven different accessions. The level of resistance as a ratio of R-to-S based on GR_{50} (50% growth reduction) varied between 12 and 49. Shikimic acid accumulation determined that the S accession accumulated 23.4- to 2.37-fold higher levels at 1000 µM glyphosate compared to levels in R accessions. At 96 hr after treatment, 35 to 44% and 61% of applied ^{14}C-glyphosate was taken up by leaves of plants from R and S accessions, respectively. At this time, a higher proportion of the glyphosate taken up remained in the treated leaf of R plants (54.7 to 69.2%) compared to S plants (35.8%). Glyphosate metabolism was low and did not differ between resistant and susceptible plants. Glyphosate was differentiy metabolized to AMPA and glyoxylate in plants of R and S biotypes, although very low in both accessions (<9.84%). Reduced absorption and translocation in *A. palmeri* appears to be one of the mechanisms contributing to resistance, because the level of resistance in some accessions is very large for just one mechanism to underlie resistance.

Research is underway to identify other mechanisms involved. However, the results confirm the first case of glyphosate-resistant *A. palmeri* from Mexico.

GENETICS OF 2,4-D RESISTANCE IN AN ILLINOIS WATERHEMP POPULATION. Sebastián Sabaté*, Patrick Tranel, Aaron G. Hager; University of Illinois, Urbana, IL (65)

A recently identified population of waterhemp (*Amaranthus tuberculatus*) from Illinois with resistance to the herbicide 2,4-D was studied to elucidate how this trait is inherited. Plant material consisted of generations derived from reciprocal crosses between the resistant population (MU) and a known 2,4-D sensitive population (WUS). Parental (P) populations of MU and WUS, reciprocal F1, F2, and backcross (BC) to sensitive populations were studied. Experiments were carried out under greenhouse conditions using cone-tainers for growing individual plants. Herbicide dose response trials on P and F1 populations were performed to identify the rate of 2,4-D that discriminates between resistant (R) and sensitive (S) plants. Dry weight and injury level (visual observation) were evaluated for each individual plant 14 to 16 d after treatment. An index combining these two measures was used to establish a threshold to define R and S individuals. Comparison of P and F1 populations indicated that the resistance trait was at least partiy dominant and nuclear inherited. A rate of 560 g a.e. ha^{-1} of 2,4-D was selected and applied to plants four to six cm t (four to six leaves) to investigate segregation in F2 and BC populations. In general, the distribution of dry weights for F2 and BC plants showed a continuous distribution rather than distinct phenotypes that would be expected for a single-gene trait. Nevertheless, when using a threshold to discriminate R and S individuals, the 3:1 R:S ratio expected for a dominant, single-gene trait was observed in both runs of one F2 population, and in one of two runs of a second F2 population. The BC to sensitive populations exhibited a 1:1 R:S segregation ratio, also consistent with a dominant, single gene trait. Collectively, the results indicated that there may be one major gene conferring resistance to 2,4-D in the MU waterhemp population, but one or more additional genes contribute to the resistance. Further studies are being conducted on this and on an additional 2,4-D-resistant waterhemp population to better clarify the genetics of the resistance.

HIGH TEMPERATURE ENHANCES THE EFFICACY, ABSORPTION AND/OR TRANSLOCATION OF 2,4-D OR GLYPHOSATE IN GIANT RAGWEED. Zahoor A. Ganie*[1], Mithila Jugulam[2], Amit Jhala[3]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Kansas State University, Manhattan, KS, [3]University of Nebraska Lincoln, Lincoln, NE (66)

Glyphosate and 2,4-D are very effective for the control of giant ragweed (*Ambrosia trifida*) before planting corn and soybean in the Midwest; however, environmental factors including temperature may influence the efficacy of these herbicides. The objective of this study was to evaluate the efficacy of 2,4-D or glyphosate for control of giant ragweed under different growth temperatures and to determine the underlying physiological mechanisms (absorption and translocation). An additional objective was included to determine the influence of growth temperatures on the level of glyphosate resistance in glyphosate-resistant giant ragweed. Glyphosate-susceptible and –resistant giant ragweed biotypes were used for 2,4-D or glyphosate dose-response studies at two growth temperatures (day/night, ^{0} C): low (LT) 20/11 and high (HT) 29/17. The results suggested an improved efficacy of 2,4-D or glyphosate at HT compared to LT on giant ragweed, regardless of susceptibility or resistance to glyphosate. The level of glyphosate resistance decreased in giant ragweed at HT. Uptake and translocation experiments indicated more translocation of 2,4-D in giant ragweed at HT compared to LT. Similarly, increased absorption and translocation in giant ragweed resulted in greater efficacy of glyphosate at HT compared to LT. In conclusion, the efficacy of 2,4-D or glyphosate for giant ragweed control can be improved if applied at warm temperature (29/17 ^{0} C d/n) due to increases in absorption and/or translocation of these herbicides compared to cooler temperatures (20/11 ^{0} C d/n).

RAINFASTNESS OF 2,4-D, ROUNDUP WEATHERMAX, LIBERTY AND COBRA. Kasey Schroeder*[1], Juan Espinoza[2], Ronald Navarrete[2], André de Oliveira Rodrigues[3], Jeffrey A. Golus[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Zamorano University, Tegucigalpa, Honduras, [3]University of Nebraska-Lincoln, Lincoln, NE (67)

Rainf is one of the many factors that can influence the effectiveness of herbicide applications. A study was conducted to determine the impact of timing of rainf following application, nozzle type and herbicide selection on weed control. The species utilized in this experiment were flax (Linum usitatissimum), oats (Avena sativa), and velvetleaf (Abutilon theophrasti), Glyphosate (roundup WeatherMax), glufosinate (Liberty), lactofen (Cobra), and 2,4-D were applied to each species with both a XR or TTI nozzle. After herbicide application, 0.6 cm of rainf was applied at eight different timings (none, 0, 5, 15, 30, 60, 120, 240 minutes after application). In general, longer time interval between herbicide and rainf applications resulted in greater control of the plant species at 28 d after treatment. Rainf effect on herbicide efficacy varied by plant species. Rainf had a greater effect on species treated with glyphosate while there was no effect on the contact herbicides glufosinate and lactofen.

DROPLET SIZE AND DEPOSITION OF GLYPHOSATE AND 2,4-D DRIFT IN A WIND TUNNEL. Matthew R. Nelson*, Bruno Canella Vieira, Annah Geyer, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (68)

Spray particle drift, or the physical movement of spray particles off-target, is dependent upon factors such as wind speed, boom height, distance from susceptible vegetation, and spray particle size. Spray particle size is affected by nozzle type, operating pressure, orifice size, and tank solution. Wind speed, wind direction, and location of susceptible vegetation are more difficult or impossible to control. Minimizing spray particle drift is an important component of applications in weed control systems that herbicide-tolerant crops such as dicamba and 2,4-D. The objective of this study was to determine the droplet size and deposition of glyphosate and 2,4-D drift in a wind tunnel. The study was conducted in the low-speed wind tunnel at the Pesticide Application Technology (PAT) Lab in North Platte, NE. Enlist Duo™ herbicide, a pre-mixture of 2,4-D choline and glyphosate in a formulation that has low drift characteristics, was applied at a rate of 592 g ae/ha glyphosate and 558 g ae ha^{-1} 2,4-D with a carrier volume of 140 l ha^{-1} through either an AIXR11004 or TDXL11004 nozzle operated at 276 kPa. The wind tunnel was operated 8, 16, and 21 kmh^{-1}. Collection stations were placed 0, 1.5, 3, 6, 9, and 12 m downwind of the nozzle. Mylar cards and strings were used to collect deposition (deposition rate and spray volume deposition), and water sensitive cards were used to collect droplet size data (volume median diameter). The study showed that deposition of a glyphosate and 2,4-D solution at downwind distances was impacted by wind speed, as higher wind speed resulted in greater deposition. Higher wind speeds also resulted in the collection of spray droplets with larger volume median diameters at distances downwind from the spray nozzle. At 21 kmh^{-1}, the volume median diameter of spray particle drift collected at each respective downwind distance (1.5, 3, 6, 9, 12 m) was 369, 265, 195, 165, and 141 µm. Additiony, spraying glyphosate plus 2,4-D through the TDXL 11004 nozzle resulted in the collection of larger spray droplets at downwind distances (1.5 and 3 m) than the AIXR 11004 nozzle. In conclusion, this study showed that while deposition is dependent upon the distance from the site of application, the volume median diameter of spray particles that move off-target increases as wind speed increases. In addition, the study showed that operating similar nozzles under uniform conditions may lead to differences in the size of spray particles that move off-target during an application.

PPO-INHIBITOR-RESISTANT RIGID RYEGRASS (*LOLIUM RIGIDUM*) AND WILD POINSETTIA (*EUPHORBIA HETEROPHYLLA*) RESPONSE TO PRE AND POST APPLIED OXYFLUORFEN. Pablo T. Fernandez-Moreno*[1], Reid Smeda[2], Rafael A. De Prado[1]; [1]University of Cordoba, Cordoba, Spain, [2]University of Missouri, Columbia, MO (69)

In Spain, as well as worldwide, rigid ryegrass (*Lolium rigidum*) is a severe weed problem in both annual and perennial cropping systems. Growers have used rigid ryegrass in Mediterranean fruit-tree groves as a cover crop to reduce soil erosion. Another species, wild poinsettia (*Euphorbia heterophylla*) is also a problem, especiy in annual cropping systems in tropical America. Protoporphyrinogen oxidase (PPO)-inhibitors have been widely utilized for effective control of both rigid ryegrass and wild poinsettia, especiy on herbicide-resistant populations. Resistance to PPO-inhibiting herbicides was identified in both species following post-emergence applications of oxyfluorfen for several years. The PPO-resistant compared to -susceptible biotypes of both species exhibited GR_{50} (50% growth reduction) and LD_{50} (50% lethal) values ranging from 20- and 11- (GR_{50}) to 39 and 14- (LD_{50}) fold higher for rigid ryegrass and wild poinsettia, respectively. Assays were conducted to determine if resistance may be exhibited by seeds of both species chenged with oxyfluorfen. Multiple seeds were placed on a nutrient-enriched agar medium containing different rates of oxyfluorfen. At 12 d after treatment, roots and shoots were partitioned and weighed. The GR_{50} value for shoots and roots of R compared to S wild poinsettia seedlings was 14 and 18, respectively. For rigid ryegrass, a similar approach resulted in a GR_{50} for shoots and roots of R and S seedlings of 3 and 13, respectively. Although the mechanism of oxyfluorfen resistance in both wild poinsettia and rigid ryegrass is not currently known, the resistance is expressed by germinating seedlings.

WHAT IS THE ROLE OF CROP INTERFERENCE IN INTEGRATED WEED MANAGEMENT OF EDAMAME? Laura Crawford*, Martin M. Williams; University of Illinois, Urbana, IL (70)

Vegetable processers cite weed interference as a major constraint to edamame (*Glycine max*) production. Recent registration of several herbicides has increased the number of tools available for weed control in edamame; however, prevalence of herbicide-resistant weed populations necessitates the development of multi-tactic weed management systems. In grain soybean, larger seed have a greater competitive advantage over weeds than sm soybean seed. Edamame seed are considerably larger than commerciy available grain soybean, yet the extent to which seed size affects edamame-weed interactions is unknown. The objective of this study was to determine the role of seed size in crop tolerance to weed interference (CT) and in the crop's weed suppressive ability (WSA). The hypothesis was that plants from larger edamame seed would have higher CT and WSA than plants from smer edamame seed. A two-year field experiment was conducted as a split-split plot design with four replications. Five edamame cultivars and one grain soybean cultivar were included. Each cultivar was separated into two discrete size classes, sm and large, based on seed diameter. Crop rows were planted both with and without velvetleaf (*Abutilon theophrasti*). CT values were calculated for each cultivar and size level by comparing the crop rows with and without velvetleaf. WSA values were calculated by comparing velvetleaf in the crop rows with velvetleaf measurements from weedy monoculture plots. The CT hypothesis was confirmed; weed interference suppressed mid-season crop biomass in treatment combinations, but plants from larger seed had higher CT than plants from sm seed of the same cultivar ($P = 0.0613$). This was likely driven by the positive correlations between crop seed size and early crop growth; crop seed size was positively correlated with crop seedling height ($P < 0.0001$) and biomass ($P < 0.0002$). The WSA hypothesis was disproven; seed size classes within a given cultivar did not affect WSA ($P = 0.1348$). However, crop cultivar choice did affect WSA ($P < 0.0001$). There are many differences between cultivars that could be causing the WSA differences, including genetic backgrounds, but cultivars also differed in seed size. Over the whole study, crop seed size was negatively correlated with mid-season weed biomass ($P = 0.0998$), but due to the low number of cultivars included in this study, results cannot be extrapolated. More research is needed to determine if this trend applies to more cultivars.

BICYCLOPYRONE: MAJOR LEAGUE WEED CONTROL IN MINOR LEAGUE CROPS. Dain E. Bruns*[1], Cheryl L. Dunne[2], Gordon D. Vail[3], Monika Saini[3], Stott W. Howard[4]; [1]Syngenta Crop Protection, Marysville, OH, [2]Syngenta Crop Protection, Vero Beach, FL, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta Crop Protection, Des Moines, IA (71)

Bicyclopyrone is a newly registered HPPD-inhibiting active ingredient for control of dicot and some grass weeds. Bicyclopyrone is one of the four active ingredients in Acuron herbicide which was registered for sales in corn in 2015. Syngenta is evaluating the potential for expanding bicyclopyrone use into minor/specialty crops where options for weed control are limited. In 2016, University and Syngenta trials evaluated both PRE and POST bicyclopyrone applications for crop tolerance and weed control in minor crops, including onion, carrot, horseradish, hops, rosemary, sweet potato, timothy and ornamentals.

CERY PEAR (*PYRUS CERYANA*), AN INVASIVE URBAN WEED: EFFECTIVE CONTROL METHODS. Matthew R. Terry*, Reid Smeda; University of Missouri, Columbia, MO (72)

Hybridization of self-incompatible ornamental pear trees (Bradford, Autumn blaze, etc.) in urban areas has resulted in a new invasive species, Cery pear. Viable seeds are readily spread by birds to non-disturbed areas and become established at high densities. Uncontrolled, Cery pear threatens native species in forest and prairie habitats. Currently, few herbicides have been examined for effective control. Trials were established at three locations across Missouri to examine the response of Cery pear to various herbicides following foliar (1.5 to 2 m trees) or cut-stump (10 to 15 cm basal diameter) applications. Foliar applications (nine treatments) were made in late summer at a spray volume of 421 l ha^{-1}. For cut-stump applications, trees were cut in December and the exposed meristematic tissue was treated within 10 min. Herbicides included single or mixed application of triclopyr, aminocylopyrchlor, and glyphosate. Foliar treatments were evaluated (0 to 100% control) at leaf emergence the following spring (eight months after treatment; MAT) and at 12 MAT. At eight MAT, treatments except picloram + fluroxypyr and picloram alone resulted in ≥90% control. At 12 MAT, foliar treatments exhibited a similar level of control, with aminocyclopyrchlor + metsulfuron and aminocyclopyrachlor + metsulfuron + imazypyr resulting in 100% control. For treated stumps, no sucker growth was evident at 12 MAT, suggesting excellent control. Suckers readily regrew for untreated controls, reaching lengths of 0.4 m by eight MAT. A number of herbicides currently available for control of undesirable tree species via foliar and cut-stump applications appear to be effective on Cery pear.

A SIMULATION TO PREDICT THE SPREAD OF ROAD DUST IN A CROP FIELD AND ITS POTENTIAL EFFECTS ON PALMER AMARANTH. Sydney Rissler[1], Teig Loge*[2]; [1]Simpson College, Ankeny, IA, [2]Simpson College, Indianola, IA (73)

Road dust, primarily found on rural gravel roads, is a particle 0.01-5000 μm in diameter and is known to block the stoma of plants in a neighboring fields resulting in poor crop growth. It is speculated that this same dust concentration on a weed, such as Palmer amaranth, may also give the weed a “shield” against herbicides. This interdisciplinary study between mathematics, computer science, and biology aims to predict the spread of road dust across neighboring fields throughout the growing season and determine herbicide effectiveness on road dust covered crops. For this preliminary portion of research, an exploratory model was built that predicts road dust accumulation in fields adjacent to rural gravel roads. In the simulation, rain, traffic volume, and traffic speed were used to calculate dust accumulation. Upon completion of the greenhouse research, the model can be updated to predict road dust contribution to herbicide resistance.

A REGIONAL MONITORING PROGRAM FOR HERBICIDE RESISTANCE IN SHATTERCANE AND JOHNSONGRASS FOLLOWING COMMERCIALIZATION OF INZEN SORGHUM HYBRIDS. Jake J. Ziggafoos*[1], Rodrigo Werle[2], Amit J. Jhala[3], John Lindquist[3], Brigitte Tenhumberg[1], Jeffrey Mower[1], Melinda Yerka[1]; [1]University of Nebraska - Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE, [3]University of Nebraska-Lincoln, Lincoln, NE (74)

‘Inzen’ grain sorghum hybrids resistant to ALS-inhibiting herbicides are in the final stages of commercialization by DuPont-Pioneer. High on-farm adoption of this technology is expected, but gene flow of ALS-resistance (ALS-R) to the weeds shattercane and johnsongrass is inevitable. Here we present the current status and future directions for a risk-assessment framework of ALS-R evolution in shattercane and johnsongrass to be used in a regional monitoring program in Nebraska and Kansas. Current (shattercane) and emerging (johnsongrass) models will be used to predict the evolution of ALS-R weeds under various cropping systems including Inzen hybrids. Molecular markers unique to Inzen hybrids will provide data on the relative frequencies of ALS-R weed evolution due to gene flow from Inzen or de novo mutations selected for by repeated ALS-inhibitor applications. Grower surveys conducted at the time of Inzen commercialization will establish a baseline estimate of where ALS-R weeds are a problem, and at five and 10 years thereafter. Grower education through extension programs will provide information on the risks associated with crop-to-weed gene flow, and will encourage no-cost self-reporting of ALS-R weeds on farms. PCR-based assays will be made available to participating universities to preliminarily screen sorghum, shattercane, and johnsongrass for Inzen eles. Additional molecular markers based on Inzen DNA sequence at the ALS locus will be used to confirm gene flow events. These data are needed by federal agencies to make science-based decisions regarding the ecological risk of introducing crop nuclear technologies (GMO and non-GMO) where sympatric wild relatives grow.

EFFECT OF GROWTH REGULATOR HERBICIDE INJURY TO COMMON MILKWEED ON OVIPOSITIONING BY MONARCH BUTTERFLIES. Brooke L. Hoey*, Sydney Lizotte-H, Bob Hartzler; Iowa State University, Ames, IA (75)

Iowa is located in the heart of the summer breeding range of the monarch butterfly (*Danaus plexippus*), and much of the *Asclepias* spp. used for oviposition and larval development are found in close proximity to crop fields. Experiments were conducted during 2016 to determine whether injury associated with sub-lethal rates of growth regulator herbicides influence ovipositing behavior of monarch butterflies on common milkweed. The first experiment was conducted at Coldwater Golf Links in Ames, IA. This course has areas of native warm-season grasses with infestations of Canada thistle and common milkweed. The course superintendent used aminopyralid as a spot treatment to control Canada thistle during May of 2016, resulting in indirect contact and injury on many common milkweed plants. At six sites on the golf course common milkweed stems were selected to include plants exhibiting a range of injury symptoms (no visible symptoms to more than four nodes with distorted leaves). Plants were examined weekly to determine the presence of monarch eggs. No differences were observed in ovipositing preference due to herbicide injury. In a second study, common milkweed was grown in the greenhouse and treated with low rates of dicamba (0, 0.56, and 5.6 g a.e. ha^{-1}) to simulate drift injury. Plants were placed at two locations at the Iowa State University Horticulture Research Farm near Gilbert, IA for two wk. Monarch eggs were counted and removed every 3 or 4 d. Egg laying on common milkweed was not affected by dicamba injury. Nearly twice as many eggs were found on plants located in a grassy area near a soybean field than on plants placed on a grassy area near a large pond and savanna. In these experiments growth regulator herbicide injury that resulted in leaf distortion on common milkweed did not affect the number of eggs found on common milkweed. Additional studies could investigate whether herbicide injury influences larval fitness or survival. This research is a component of the Iowa Monarch Conservation Consortium efforts to enhance the Iowa landscape to support increased reproduction of the monarch.

COMMON MILKWEED INJURY DUE TO FOMESAFEN EXPOSURE AND ITS IMPACT ON MONARCH UTILIZATION. Sydney E. Lizotte-H*, Bob Hartzler; Iowa State University, Ames, IA (76)

The adoption of glyphosate-resistant crops and resulting use of glyphosate has been one of the hypothesized causes for the declining population of the monarch butterfly (*Danaus plexippus*). Although glyphosate has reduced common milkweed (*Asclepias syriaca*) presence in agricultural crop fields, there is little information documenting the importance of milkweeds in crop fields for monarch reproduction prior to the loss of milkweed from the habitat. We conducted field and greenhouse experiments investigating impacts of the herbicide fomesafen on common milkweed growth and oviposition preference of monarchs. Common milkweed seedlings were transplanted in patches containing five plants spaced 25 cm apart in a no-till soybean field shortly after soybean planting. Treatments included an untreated control and 0.14 kg ha^{-1} fomesafen plus 0.5% v v^{-1} crop oil concentrate. Soybean were planted on May 5, 2016 and the fomesafen was applied on June 24, 2016 when common milkweed was approximately 20 cm t. Dry weight of common milkweed plants were measured before herbicide application and again 10 wk after application. Biomass was not affected by fomesafen. Common milkweed plants were examined weekly from May 10, 2016 to August 22, 2016 to determine whether herbicide injury influenced oviposition preference of monarch butterflies. Fifteen eggs were found on the 120 common milkweed plants prior to fomesafen application. During this time frame the common milkweed was ter than soybean plants. During July, four eggs were oviposited on milkweed with no preference between treated and untreated plants. At this time the common milkweed and soybean were similar in height. In mid-August, ten pots each containing one common milkweed were placed at the edge of the soybean field on a grass eyway approximately five m from the common milkweed within the field for one wk. Monarchs utilized of these plants, with one plant having 14 eggs oviposited on it. A greenhouse study examined milkweed response to four rates of fomesafen (0.03, 0.07, 0.14 kg/ha, and 0.28 kg ha^{-1}) plus 0.5% v v^{-1} crop oil concentrate applied when common milkweed was 20 cm in height. Common milkweed dry weight was different among treatments (p-value < 0.0001). The primary objective of this project was to determine the utilization of common milkweed within crop fields by monarchs. Transplant shock of common milkweed seedlings may have reduced oviposition early in the season. Common milkweed placed outside of the field in August were used much more heavily by monarchs than host plants within the soybean field. The experiment will be repeated in 2017 using plants that generate from the rootstocks of plants established in 2016 in addition to starting a second experiment with new plantings of milkweed.

MECHANISMS OF WEED EMERGENCE RESPONSE TO TILLAGE AND COVER CROPPING: IMPACTS OF HERBICIDES AND FUNGAL PATHOGENS. Markah Frost*, Daniel C. Brainard; Michigan State University, East Lansing, MI (77)

Strip-tillage (ST) can reduce input costs while protecting and improving soils. However weed management under ST can be chenging, especiy for vegetable crops with limited herbicide options. The objectives of this study were 1) to evaluate the effects of tillage (ST vs. full-width-tillage) and cover crops (none, rye or vetch) on summer annual weed emergence, and 2) to evaluate the extent to which these effects were mediated by fungal pathogens or changes in herbicide efficacy. Tillage and cover crop treatments were imposed on the same plots for six years in a sweet corn-snap bean-cucurbit rotation in two adjacent fields on sandy soils in SW Michigan. In year seven in each field (2015 and 2016), herbicide and fungicide sub-subplots were established. Herbicide treatments consisted of either no herbicide application or an application of S-metolachlor one d after planting sweet corn. Seeds of Powell Amaranth and large crabgrass that were either untreated or coated with fungicide (captan, trifloxystrobin and metalaxyl) were sown in separate sub-subplots not receiving herbicides. For both Powell amaranth and large crabgrass, emergence was suppressed in one of two years in ST + rye compared to other treatments. In one of two years fungicide treated Powell amaranth seeds had greater emergence than untreated seeds, but this effect was independent of tillage and cover crop treatment. The efficacy of S-metolachlor on common lambsquarters was reduced in ST + rye or ST + vetch compared to other treatments. These results suggest that 1) fungal pathogens did not play a role in the observed effects of tillage and cover crops on weed emergence, and 2) the efficacy of S-metolachlor is reduced by both vetch and rye cover crop surface residues.

FITNESS OUTCOMES RELATED TO HERBICIDE RESISTANCE IN WEEDS: WHAT LIFE HISTORY STAGE TO EXAMINE? O. Adewale Osipitan*[1], Anita Dille[2]; [1]Agronomy Department, Kansas State University, Manhattan, KS, [2]Kansas State University, Manhattan, KS (78)

Literature reviews have shown that fitness costs as a result of evolution of herbicide resistance in plant are not wide-ranging. Conducting studies to identify differences across several different life history stages between herbicide-resistant and -susceptible populations may detect fitness costs. A fast-spreading weed, *Kochia scoparia* (kochia), has evolved resistance to a widely-used herbicide (glyphosate). Understanding the relationship between the evolution of glyphosate resistance and kochia fitness may suggest a more effective way of controlling kochia. A study was conducted to assess fitness cost of glyphosate resistance compare to susceptibility in kochia populations at different life history stages; that is seed germination, increase in plant height, d to flowering, biomass accumulation at maturity, and fecundity. Six kochia populations evaluated were from Scott, Finney, Thomas, Phillips, Wace, and Wichita counties in western Kansas. Based on *in vivo* shikimate accumulation assay and screening with a field-use rate of glyphosate, three kochia populations were grouped into glyphosate-resistant (GR) (Scott (SC-R), Finney (FN-R), and Thomas (TH-R)) and three populations were grouped into glyphosate-susceptible (GS) (Phillips (PH-S), Wace (WA-S) and Wichita (WI-S)). Seed germination characteristics were evaluated in growth chambers at three constant temperatures (5, 10 and 15 C) while vegetative growth and fecundity responses were evaluated through a field study using a target-neighbor competition design in 2014 and 2015. Within the life history stages measured, fitness difference between the GR and GS kochia was consistently found in their germination characteristics. The GR kochia showed reduced seed longevity, germination rate and total germination compared to the GS kochia. But once seedlings emerged in the field, increase in plant height, biomass accumulation and fecundity were not different between GR and GS kochia populations. Hence, weed management plans should integrate practices that take advantage of the relatively poor germination characteristics of GR kochia. This study suggests that evaluating plant fitness at different life history stages can increase the potential of detecting fitness costs.

ANTAGONISTIC EFFECT OF GLYPHOSATE AND DICAMBA TANK-MIX ON KOCHIA CONTROL. Junjun Ou*[1], Curtis R. Thompson[1], Phillip W. Stahlman[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Research and Extension, Hays, KS (79)

Kochia (*Kochia scoparia*) is one of the most troublesome weeds of the Great Plains of North America. Glyphosate and dicamba have been used for decades to control kochia. As a result of extensive selection, glyphosate- and dicamba-resistant kochia (GDR) populations have evolved across the Great Plains, including Kansas. Tank-mixtures of dicamba and glyphosate may offer a viable option for controlling GDR kochia if these two herbicides act synergisticy. To investigate this possibility, different rates (19 combinations) of glyphosate and dicamba tank-mixtures were tested in the greenhouse and field conditions by comparing with a known susceptible kochia population (GDS). To determine the physiological basis of interaction of these two herbicides. Uptake and translocation experiments were also conducted. The results of greenhouse and field study indicate that the tank-mixtures had satisfactory control of GDS kochia. On the contrary, glyphosate alone provided the best control of GDR kochia under both greenhouse and field conditions, but the efficacies of tank-mixtures with dicamba were lower than when glyphosate applied alone. The results of physiological studies indicate that the tank-mixture of dicamba and glyphosate has a substantial antagonistic effect due to reduced translocation of both dicamba and glyphosate. In conclusion, tank-mix of dicamba and glyphosate may not be a viable option for controlling dicamba- and glyphosate-resistant kochia.

ENVIRONMENT AND HORMONE EFFECTS ON SEED GERMINATION BEHAVIOR OF KOCHIA. Anita Dille, Mithila Jugulam, Samida Khadka*; Kansas State University, Manhattan, KS (80)

Kochia seed germination was investigated in relation to various regimes of temperature, water potential, and the hormones of abscisic acid (ABA), or gibberellins (GA) and their respective inhibitors flurodine (FL) and paclobutrazol (PL). The objectives of the study were to 1) investigate the rate of kochia seed germination at low temperature and with moisture stress and the level at which no germination occurs and 2) determine the impact of exogenous application of hormones in seed germination of kochia. Seed from four kochia accessions (KS-1, KS-2, KS-3 and KS-4) were collected from a common garden field experiment near Manhattan, KS in the f of 2015. KS-3, whose initial germination was higher was used to study the effects of ABA and KS-4, with lower initial germination rate was used to study effects of GA, and KS-1 and KS-2 used to study the impact of temperature and moisture. Three temperature levels (4, 6 and 11 C) and five moisture stress levels (-0.4 MPa, -0.8 MPa, -1.2 MPa and -1.6 MPa), seven treatments of ABA (Water, 10 µmolar (µM) ABA, 10 µM ABA +2.5 µM FL, 10 µM ABA +5 µM FL, 10 µM ABA +15 µM FL, 10 µM ABA +20 µM FL, 10 µM ABA +10 µM GA) and seven treatments of GA (Water, 10 µmolar (µM) GA, 10 µM GA +2.5 µM PL, 10 µM GA +5 µM PL, 10 µM GA +15 µM PL, 10 µM GA +20 µM PL, 10 µM ABA +10 µM GA) were evaluated. Fifty kochia seed from each accessions were placed on filter paper in petri dishes for each combination of temperature, moisture (with five replications) and hormones level (with four replications studied at either 23 C or 6 C). Moisture levels were created by adding increasing amounts of polyethene glycol-8000 solution to each dish according to Michel (1983). Petri dishes were sealed with parafilm throughout the experiment to minimize moisture loss. Growth chambers were set at above mentioned levels of temperature with a 24 hr dark period. Counts were taken daily by removing germinated seeds until no more germination occurred. Petri dishes with -0.4 MPa water potential represented a field situation where enough water was present to trigger germination, but becomes limiting as the potential increases to -1.6 MPa. Final cumulative percentage germination was plotted against day of observation for each treatment combination and sigmoidal curves were fitted using SigmaPlot v.12. None of the seeds germinated at -1.6 MPa water potential for any temperature level. When placed in pure water, percentage of seeds germinated at 11, 6, and 4 C was 80, 80 and 60%, respectively for KS-1 seed lot. Similarly, 80, 60 and 50% was the total percentage of seeds germinated at 11, 6 and 4 C, respectively for KS-2 seed lot. For each temperature level, there was delay in germination as moisture stress level increased. For KS-2 at 6 C, number of d required for 50% germination in water was 6.4 d, and increased from 7.7 to 15.8 d as the moisture decreased. Temperature played a major role in triggering the physiological phenomenon that guides germination. For both seed lots, radical emergence was observed as soon as two d after adding moisture at 11 C, whereas, it took 11 d for the process to begin as temperature decreased to 4 C. Germination rate decreased with increasing level of moisture stress and increased with increasing temperature for both seed lots. Hence, we can conclude that kochia germination was inhibited at -1.6 MPa, and at 4 C and -1.2 MPa. Seeds require some time to accumulate that enough moisture to germinate at low temperature. For KS-3 seed lot exogenous application of 10 µM ABA reduced it's germination from 98% to 70%, similarly 10µM GA increased the germination rate of KS-4 seed lot to 90% from 75%. Result from the analysis of variance on the total germination revealed there was an effect of temperature and treatment combination of ABA and GA.

EFFECT OF COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L.) AND COMMON WATERHEMP (*AMARANTHUS RUDIS* SAUER) ON SOYBEAN (*GLYCINE MAX* L.) GROWTH. Koffi Badou Jeremie Kouame*; University of Nebraska-Lincoln, Lincoln, NE (81)

Common ragweed and common waterhemp are problematic weeds encountered in mixtures in soybean fields in Nebraska. Yet their mutual effect on crop growth is not well understood. Field experiments were conducted in Nebraska in 2016 to determine the influence of variable water supply on their combined effect on soybean growth. The experiment was a split-plot design with four replicates. Three irrigation levels (full irrigation, half irrigation, and no irrigation) as the main plot and four weed densities as the subplot. The experiment was set up as an additive design where common ragweed and common waterhemp were seeded at a high rate and thinned to an appropriate ratio of 50:50 (0, 1, 3, 6) giving total weed densities of 0, 2, 6, and 12 plants m^{-1} of row. Common waterhemp emerged 12 d after soybean while common ragweed emerged four d after soybean. Four samplings were made during the growing season for growth analysis at 34, 53, 81, and 102 d after soybean emergence (i.e. at 504, 767, 1182, 1431 growing degree d (GDD)). The multispecies rectangular hyperbola was fit to soybean total biomass at each sampling date. The model coefficients, mean weed-free total biomass, percent biomass loss as density approaches zero, and maximum biomass loss as weed density approaches infinity were not different between water levels. As there was no water effect on competition, the data were pooled for each sampling date. Results reveal that common ragweed was more competitive than common waterhemp for four sampling dates. Biomass losses associated with the first equivalent common ragweed plant at each sampling date were 13, 14, 46, and 92%, respectively while the maximum total biomass losses for each sampling date were 37, 51, 52, and 65%, respectively. The maximum weed-free total biomass estimates at the different sampling dates were 124, 323, 675, and 838 g/ m^{-1}, respectively.

DISTRIBUTION OF GLYPHOSATE-RESISTANT GIANT RAGWEED (*AMBROSIA TRIFIDA* L.) IN NEBRASKA. Lia Marchi Werle*[1], Spencer L. Samuelson[2], Greg R. Kruger[2]; [1]University of Nebraksa-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, North Platte, NE (82)

Giant ragweed (*Ambrosia trifida* L.) is a geneticy variable species, capable of rapidly evolving in response to herbicide selection pressure. Over-reliance on glyphosate for weed management in glyphosate-resistant (GR) crops has led to the evolution of GR weeds, including giant ragweed. The objective of this study was to identify the frequency and distribution of GR giant ragweed in Nebraska. A total of 28 populations were collected from 21 counties during the f 2014 and 2015. The experiment was conducted under greenhouse conditions in North Platte, NE. Plants were treated at 10-15 cm with the following rates of glyphosate: 0, 217, 434, 868, 1736, 3472, and 6946 g a.e. ha^{-1} using a single nozzle research track sprayer calibrated to deliver 94 l ha^{-1} at 414 kPa using a AI9502EVS nozzle. The experiment was organized in a completly randomized design with at least four replications. The experiment was replicated twice. At 28 d after treatment, visual estimations of injury were recorded on a 0-100 scale and plant biomass was recorded. Data were fitted to a non-linear regression model using the drc package in R (version 3.1.1). The effective dose (g ha^{-1}) to control 50% and 90% of the population (ED_{50} and ED_{90}) values were estimated for each population using a four parameter log logistic equation: y=c+(d-c/1+exp(b(logx-loge))). One population was resistant to glyphosate (ED_{50} = 283 ± 42; ED_{90} = 4280 ± 1205) while four populations showed levels of resistance. The most resistant population required an ED_{90} of 4280 g ha^{-1} while the most susceptible required an ED_{90} of 14 g ha^{-1}. The information obtained from this survey will improve the management of herbicide resistance in giant ragweed populations and other undesirable weeds.

IMPACT OF RAINF ON RESIDUAL ACTIVITY OF DICAMBA ON FOXTAIL (*SETARIA SPP.*) AND MORNINGGLORY (*IPOMOEA SPP.*) GERMINATION AND GROWTH. en J. Scott*, Carey Page, Reid Smeda; University of Missouri, Columbia, MO (83)

Integration of dicamba into weed management programs for tolerant soybeans offers growers an additional herbicide mode-of-action. Although dicamba exhibits post-emergence activity, damage to emerging broadleaf plants is observed for some time after dicamba application, suggesting potential residual activity. In 2016, a field study was established in central Missouri that focused on elucidating possible residual activity of dicamba on foxtail (*Setaria* spp.), amaranth, and morningglory (*Ipomoea* spp.) seedlings. Bottom-less polypropylene containers were pushed into cultivated soil, where three PVC (20 cm diameter) pieces (termed rings) were pushed into the soil. Waterhemp (*A. tuberculatus*), yellow foxtail (*S. pumila*) and morningglory seeds were spread on the soil surface and lightly covered. Dicamba from 0.14 to 1.12 kg a.e. ha^{-1} as well as flumioxazin (0.072 kg a.i. ha^{-1}) and acetochlor (1.27 kg a.i. ha^{-1}) alone or with dicamba (0.56 kg ha^{-1}) were applied. Within 30 min, rainf from 0 to 2.5 cm was applied to each ring to activate the herbicides. After the initial rainf, no rain was permitted inside containers; lids were placed on containers as necessary. Natural rainf during this research was high, and sub-soil moisture was sufficient to sustain continued weed emergence in plots. Weed emergence was monitored up to 31 d after treatment (DAT), and weed biomass was also recorded. For many evaluation dates, weed emergence levels were similar across rainf rates, suggesting rainf did not improve nor decrease herbicide activity. Morningglory emergence was not impacted by dicamba at any rainf rates, but was reduced up to 90% by flumioxazin. At 11 DAT, yellow foxtail exhibited a step-wise reduction in emergence from low (10%) to high (55.8%) rates of dicamba. Treatments containing flumioxazin and acetochlor reduced emergence by 63 and 81%, respectively. The addition of dicamba increased flumioxazin suppression of emergence by 8%. By 21 DAT, suppression of yellow foxtail remained evident, and ranged from 3.8 to 48.3% for low to high rates of dicamba, respectively. For waterhemp at 18 DAT, a step-wise reduction in emergence was measured, with low to high rates of dicamba resulting in 16.7 to 69.4% reduced emergence, respectively. Acetochlor and flumioxazin reduced emergence during this period up to 96.9%. Results indicate that dicamba reduces emergence of waterhemp and yellow foxtail up to 21 d after initial application. Although levels of suppression are not sufficient to preclude the use of traditional residual herbicides, dicamba can supplement control of residual materials.

RESPONSE OF WATERHEMP POPULATIONS FROM NEBRASKA TO SOIL APPLIED PSII AND PPO HERBICIDES. Felipe Faleco*[1], Bruno Canella Vieira[2], Spencer L. Samuelson[2], Liberty Butts[2], Greg R. Kruger[2], Rodrigo Werle[2]; [1]Sao Paulo State University, Botucatu, Brazil, [2]University of Nebraska-Lincoln, North Platte, NE (84)

Common waterhemp (*Amaranthus rudis*) is a troublesome summer annual broadleaf weed species that has developed resistance to glyphosate and other herbicide modes-of-action in Nebraska. The use of soil applied herbicides is highly recommended for herbicide-resistance management. The objective of this study was to evaluate the response of 109 common waterhemp populations collected in 2014 in Nebraska to soil-applied PSII and PPO herbicides sprayed at label rates. Herbicide treatment consisted of atrazine (1345 g ai ha^{-1}), metribuzin (560 g a.i. ha^{-1}), sulfentrazone (280 g a.i. ha^{-1}), and control (no herbicide) with four replications. The experiment was conducted in 9 cm square plastic pots filled with regular soil (Loam soil, pH = 6.4, and 1.7% OM). A volume of 0.04 ml of seeds was planted per pot (average of 90 seeds; seeds were slightly incorporated in the soil surface). The herbicides were applied immediately after planting using a spray chamber calibrated to deliver 94 l ha^{-1} using AIXR110015 nozzles at a pressure of 276 kPa. After spraying, pots were placed in a greenhouse with controlled temperature and were watered daily. At 30 d after treatment, the total number of established plants per pot was recorded. Plants were then harvested, dried to constant weight at 60 C, and dry weight per pot recorded. The percent reduction in total plant density and biomass was calculated for each herbicide treatment. Metribuzin and sulfentrazone controlled populations tested (100% density reduction). For atrazine, 103, 46, and 12 populations had less than 90, 50, and 10% reduction in plant density, respectively. Moreover, 98, 39, and 15 populations presented less than 90, 50, and 10 % reduction in total biomass, respectively. The same study will be replicated and further studies will be conducted to evaluate the response of these populations to higher atrazine rates. According to our preliminary results, metribuzin and sulfentrazone, which are commonly used soil-applied herbicides in soybeans, are still effective for common waterhemp management. Atrazine, which is commonly used for weed management in corn, was not very effective on several common waterhemp populations from Nebraska at the rate used in this study. No cross-resistance to atrazine and metribuzin was identified in this study. Selection of effective soil-applied herbicides can assist growers achieve better common waterhemp control and ameliorate the issues with herbicide resistance.

PALMER AMARANTH (AMARANTHUS PALMERI) SUPPRESSION WITH HALF RATES OF DICAMBA AND ATRAZINE WITH INCREASING SORGHUM (SORGHUM BICOLOR) DENSITY AND NITROGEN RATE. IVAN B. Cuvaca*[1], Rand S. Currie[2], Mithila Jugulam[1], Anserd Foster[3]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Univ., Garden City, KS, [3]Kansas State University, Garden City, KS (85)

Palmer amaranth competition can result in severe yield losses in grain sorghum. Nevertheless, increasing sorghum density and nutrient supply could promote early canopy closure which can reduce the amount of light that could otherwise penetrate the canopy and promote Palmer amaranth growth in sorghum production. A study was conducted at Kansas State University Southwest Research-Extension Center near Garden City, KS to determine if Palmer amaranth could be suppressed with dicamba and atrazine applied as PRE at half rates combined with increasing sorghum density (60,000, 90,000 and 120,000 seeds ac^{-1}), and nitrogen rate (0, 100, 200 lbs ac^{-1}). Preliminary results indicate that increasing plant density and nitrogen rate did not suppress Palmer amaranth growth. The increase in plant density and nitrogen rate had no impact on reducing Palmer amaranth height, number, and biomass in plots without in season control. In season control of Palmer amaranth ly ($p < 0.01$) increased grain yield, sorghum height and number of heads. In season control was required to maximize yield. These results suggest that increasing plant density within the row does not reduce light penetration into sorghum canopy to suppress Palmer amaranth growth. Narrow-row planting will be added to the treatment structure to further determine the effect of plant density on suppressing Palmer amaranth in irrigated sorghum production.

DOES ROAD DUST HAVE THE POTENTIAL TO IMPACT CHEMICAL CONTROL OF WATERHEMP (*AMARANTHUS TUBERCULATUS*)? Kayla Price*, Clint K. Meyer, Zoe G. Muehleip, Maggie E. Long, Rick Spellerberg; Simpson College, Indianola, IA (86)

Waterhemp (*Amaranthus tuberculatas*) is a common weed in agricultural systems throughout the midwestern U.S. Control of waterhemp can be difficult because of high growth rates, plant densities, seed production, and late emergence in the growing season. A key component in waterhemp management includes herbicide application. Herbicides can be impacted by many factors including timing of application, plant resistance, and environmental conditions. A common factor that impedes effectiveness of herbicides is the interaction with road dust. Road dust has been shown to decrease control of other weed species and may accelerate herbicide resistance. We propose to assess the interaction between road dust and herbicide efficacy in waterhemp. In a controlled greenhouse environment, we will coat plants with a range of dust rates, both before and after glyphosate or dicamba application. We will then quantify plant mortality to assess dust impacts on chemical control. Furthermore, we will measure plant height, wet weight, and dry weight to assess how dust might impact non-lethal herbicide effects. We hope that our results will help us assess the interaction between road dust and herbicide efficacy, and how road dust might contribute to herbicide resistance. We also hope to extrapolate our results to other weed species within the genus, including the increasingly problematic, invasive Palmer amaranth.

DENSITY DEPENDENT JOHNSONGRASS (*SORGHUM HALEPENSE*) SEED PRODUCTION. Don G. Treptow*; University of Nebraska - Lincoln, Ithaca, NE (87)

Understanding the population dynamics of Johnsongrass is key to predicting its expansion into new agricultural systems. An important demographic component of these dynamics is density dependent seed production. Research was conducted in 2016 and 2017 to investigate density-dependent Johnsongrass seed production under Midwest conditions. Johnsongrass seeds from multiple infested corn, soybean, sorghum, and fow fields in Kansas, Missouri, and Nebraska were collected. A counting square was used to determine Johnsongrass culm density, and panicles within this area were harvested. Seeds were manuy threshed and counted using a seed counter. Germination probability of fresh seeds from each population were evaluated in a germination chamber. Viability of ungerminated seeds were tested using the tetrazolium seed test procedure. Initial analyses indicate a nonlinear relationship between Johnsongrass culm density and seed production. The number of Johsongrass seeds produced in each cropping system in decreasing order is corn, soybean, fow, and sorghum. Results will be used to estimate the parameters of a function modeling density dependent seed production of Johnsongrass under cropped and fow conditions.

QUANTIFYING THE ORIGIN OF RESISTANCE. Federico Casale*[1], Patrick Tranel[2]; [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University of Illinois, Urbana, IL (88)

Because herbicide resistance is a chenge in current crop production, weed management strategies should include resistance mitigation methods. To design successful resistance mitigation strategies, it is indispensable to know how resistant populations are generated. Although it is known that herbicide resistance has three possible origins—the standing genetic variation in the weed population, immigration via pollen or seeds, and *de-novo* mutations—how much each of these three sources contributes to resistance evolution remains unknown. Here, we present a method to quantify how often a resistant individual arises from *de-novo* mutations in a sensitive population. As a model system, we are using resistance to ALS-inhibiting herbicides in grain amaranth (*Amaranthus hypochondriacus*). We aim to generate 100 million grain amaranth individuals, and screen these for resistance to imazethapyr. Seed production and resistance screening is being conducted in a batch-wise process, and results to date will be presented.

UNDERSTANDING GENDER DETERMINATION IN DIOECIOUS AMARANTHUS WEEDS. Ahmed Sadeque*[1], Patrick Brown[2], Patrick Tranel[3]; [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Illinois at Urbana-Chamapaign, Urbana, IL, [3]University of Illinois, Urbana, IL (89)

Evolution of multiple herbicide resistance in waterhemp (*Amaranthus tuberculatus*) poses a large threat to the agricultural community. One of the characteristics aiding waterhemp in evolving resistance is its dioecious nature. The genetics and evolution underlying this dioecious nature of the plant are still not understood. In current work, we are utilizing Restriction-site Associated DNA sequencing (RAD-seq) to gain insights into the sex-determination mechanism in waterhemp. RAD-seq was performed on nearly 200 each of male and female plants using the Illumina platform, and the data were analyzed with TASSEL (Trait Analysis by aSSociation, Evolution and Linkage) with a goal of identifying gender-specific tags. Analysis of the tags owed us to identify 4671 male-specific and 1523 female-specific tags. Male-specific tags tended to be present in the vast majority of males, whereas female-specific tags were present in less than one-fourth of females. Many of the female-specific tags exhibited high sequence similarity to the male-specific tags. Collectively, these observations are consistent with previous reports that males are the heterogametic sex in waterhemp, and also reveal the potential presence of a cryptic male genomic region in some females. Candidate gene analysis was carried out by aligning male-specific tags to waterhemp transcriptome data available at NCBI. Out of 4671 male-specific tags, 528 showed homology to the transcriptome data with an e-value of less than $1e^{-10}$. Gene ontology (GO) terms were obtained for transcripts aligning to these 528 tags: 129 transcripts were associated with biological processes, 152 with molecular functions and 156 with cellular components. An important finding through the GO term analysis was the identification of eight transcripts associated with reproduction (GO:0000003) and 14 transcripts with developmental processes (GO:0032502). Five transcripts were associated with pollen germination (GO:0009846), consistent with their male specificity. A subset of male-specific tags was used to develop PCR-based markers for gender identification. Such markers from six different male-specific tags consistently distinguished male and female waterhemp plants.

INVESTIGATIONS OF 2,4-D AND MULTIPLE HERBICIDE RESISTANCE IN A MISSOURI WATERHEMP POPULATION. Blake R. Barlow*, Meghan Biggs, Mandy Bish, Kevin Bradley; University of Missouri, Columbia, MO (90)

ANALYSIS OF WEED SPECIES SPECTRUM AFTER A FOUR YEAR CORN AND SOYBEAN ROTATION WITH GROWTH REGULATOR HERBICIDE DEPENDENT WEED CONTROL PROGRAMS. Travis Legleiter*, William G. Johnson; Purdue University, West Lafayette, IN (91)

The introduction of the 2,4-D- and dicamba-resistant soybean systems will bring an additional tool to farmers for control of tough and herbicide-resistant broadleaf weeds in soybean. Indiana farmers dealing with marestail (*Conyza canadensis* (L.) *Cronq*), common waterhemp (*Amaranthus rudis Sauer*), giant ragweed (*Ambrosia trifidia L.*), and Palmer amaranth (*Amaranthus palmeri S. Wats.*) are likely to quickly adopt new technologies for the benefit of using growth regulators in soybean. The new technologies must be stewarded to prevent the overuse of the growth regulator herbicides as the primary site-of-action for the control of tough-to-control dicot weeds. The overreliance on the growth regulator herbicides is likely to lead to further herbicide resistance events and weed species shifts. A no-till trial was initiated during the 2013 growing season and carried out through 2016 at the Southeast Purdue Agricultural Center in North Vernon, IN. The four-year trial consisted of a corn and soybean rotation in a split block with four treatments each representing the 2,4-D and dicamba systems. Treatments consisted of the following programs: integrated Roundup Ready system without growth regulators (IntRR), integrated growth regulator system with residual herbicides in both corn and soybean(IntGR), fully integrated system that includes multiple modes of action and growth regulators in soybean (FullInt), and growth regulator reliant system with a glyphosate plus growth regulator only applications used three times in each season (GR). Weed counts were conducted prior to every herbicide application in two preset meter square areas within each plot. Counts prior to the burndown application each spring did not show a shift in early spring weed species or densities over the first four-year span for any of the programs. Although counts taken prior to post-emergence applications showed a decrease in weed density and species spectrum in the three integrated systems (IntRR, IntGr, & FullInt) as compared to the GR over the four year period. The trial is to scheduled to continue for an additional four years to evaluate species shifts over an eight-year period as well as evaluation of soil collections for seed bank shifts. While a major weed species shift was not observed at the four-year mark, the high density of weeds and number of species receiving growth regulator herbicide applications in the GR system indicates a high selection pressure situation in which herbicide resistance is likely to occur.

DISTRIBUTION OF GLYPHOSATE-RESISTANT COMMON WATERHEMP (*AMARANTHUS RUDIS*) IN NEBRASKA. Bruno Canella Vieira*[1], Spencer L. Samuelson[1], Jose H. Sanctis[2], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]ESALQ-USP, Sao Paulo, Brazil (92)

Common waterhemp (*Amaranthus rudis Sauer*) is a C4 summer annual weed species, member of the Amaranthaceae family, and native to North America. It has rapid growth and prolific seed production that contribute to its success as a weed. Yield losses up to 56% were reported in soybeans and up to 74% in corn from competition with common waterhemp. Several common waterhemp populations have been reported resistant to ALS inhibitors, Photosystem II inhibitors, EPSP synthase inhibitor, PPO inhibitors, TIR1 auxin receptors, and HPPD inhibitors in the U.S. The objective of this study was to investigate the susceptibility of common waterhemp populations from Nebraska to glyphosate. Common waterhemp populations were sampled in Nebraska and were subjected to a glyphosate-dose response study, in which different rates of glyphosate (0, 39, 434, 868, 1736, 3472, and 6935 g a.e. ha^{-1}) were applied to 12 cm t plants using a single nozzle research track sprayer calibrated to deliver 94 l ha^{-1} with a Teejet AI95015EVS nozzle at 414 kPa. Visual estimations of injury and above ground biomass were recorded 21 d after treatment. Data were fitted to a non-linear regression model with the drc package in R 3.1.2. The I_{50}, I_{90}, GR_{50} and GR_{90} values were estimated for each population using a four parameter log logistic equation. The results confirm the presence of glyphosate-resistant common waterhemp in Nebraska. Identifying the distribution and the level of glyphosate-resistance is an important part of the integrated weed management (IWM) and a key factor for the successful control of common waterhemp in Nebraska.

RESPONSE OF PALMER AMARANTH (*AMARANTHUS PALMERI*) TO GLYPHOSATE AND PPO-INHIBITING HERBICIDE TANK-MIXTURES. Jesaelen G. Moraes*[1], Thomas R. Butts[2], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (93)

Palmer amaranth (*Amaranthus palmeri S. Wats*) is one of the most invasive, competitive, and aggressive pigweed species. It has become a major agricultural chenge due to its rapid growth, aggressive competition, germination throughout the season, high fecundity, and the evolution of resistance to different herbicide modes-of-action. One of the alternatives to prevent the evolution of resistance is the use of tank-mixtures containing herbicides for post-emergence applications. The objective of our research was to observe the response of Palmer amaranth to glyphosate and PPO-inhibiting herbicide tank-mixtures. The study was conducted as a randomized complete block factorial design in two different fow fields located in Beaver City, NE. Mixtures containing PPO-inhibiting herbicides (fomesafen at 0.13 kg a.i. ha^{-1} or lactofen at 0.22 kg a.i. ha^{-1} were applied with AMS at 2.5% v v^{-1} and COC at 1% v v^{-1}. Tank-mixtures using glyphosate at 1.2 kg ae ha^{-1} were applied with AMS at 2.5% v v^{-1}. PPO-inhibiting herbicides and glyphosate were applied both alone and in combination in a factorial arrangement of treatments. Each treatment was applied at 187 l ha^{-1}, 9.6 kph, and 275 kPa. Three different nozzles with the same orifice size (11004) were used: XR, AIXR, and TTI. Applications were made using a CO_2 sprayer mounted to a Bobcat 3400 UTV with a four nozzle boom, nozzles spaced 50 cm apart, and boom height at 50 cm above the plants. After application, visual estimations of injury were collected at 7, 14, 21, and 28 d after application (DAA). Furthermore, droplet size spectra were generated for these treatments using a low- speed wind tunnel at the Pesticide Application Technology Lab in North Platte, NE, with a Sympatec HELOS-VARIO/KR 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 (p<0.0001) for droplet size spectra, a nozzle effect was not for control of Palmer amaranth. Glyphosate alone and glyphosate plus lactofen provided the best control of Palmer amaranth by increasing the visual estimations of injury by 8, 47, and 54% compared to solutions glyphosate plus fomesafen, lactofen alone, and fomesafen alone, respectively. Moreover, the interaction between nozzle and solution had an impact on the percent of fine droplets (<150 µm) produced. The percent of fine droplets were considerably increased when glyphosate was used alone in combination with the XR nozzle, followed by the AIXR nozzle, whereas TTI nozzle remained unchanged. Therefore, based on this study since nozzle (and thereby, droplet size) did not influence control of Palmer amaranth, it would be recommended to use TTI nozzles as the larger droplets would minimize the drift potential of the spray application.

CONTROL OF PALMER AMARANTH (*AMARANTHUS PALMERI*) AND COMMON LAMBSQUARTERS (*CHENOPODIUM ALBUM*) WITH TANK-MIXTURES OF CLETHODIM AND DICAMBA. Andrea Rilakovic*, Isidor Ceperkovic, Kasey Schroeder, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (94)

Common lambsquarters (*Chenopodium album* L.) is one of the most problematic weeds in agriculture. It is a summer annual weed. What makes this weed difficult to control with post-emergence herbicide are wettability and foliar uptake because of the epicuticular wax on the plant leaves surface. Palmer amaranth (*Amaranthus palmeri* S. Wats.) is an invasive and aggressive C4 weed. It is a member of the Amaranthaceae family which is native in North America. It has become one of the most problematic weeds in corn, cotton, and soybean in the U.S. The objective of this study was to understand the efficacy of tank-mixtures of dicamba and clethodim on control of common lambsquarters and Palmer amaranth in a dose response experiment with a factorial arrangement of treatments using both herbicides. The plants were grown in a greenhouse under controlled conditions. Plants were treated when they reached 10^{-1}5 cm in height. Each treatment had four replications with an individual plant being considered a single rep. The treatments were applied using a single nozzle track sprayer with a TeeJet AI95015EVS nozzle at 414 kPa pressure. Height between nozzle and target was 38 cm. Two separate trials were conducted in a randomized complete block design with 49 different tank-mixtures of dicamba and clethodim. Concentrations of clethodim (0, 0.25, 0.5, 1, 2, 4 and 8X) were applied in combinations with dicamba (0, 0.25, 0.5, 1, 2, 4 and 8X) where 1X of clethodim was 0.13 kg a.i. ha $^{-1}$ and dicamba was 0.28 kg a.e. ha $^{-1}$. Visual estimations of injury and above ground biomass were recorded 28 d after treatment. Data were fit to a nonlinear regression model with the drc package in R 3.1.2. The estimated effective doses to reduce weed biomass by 50 and 90% were estimated for each population using a four parameter log logistic equation: y=c+(d-c/1+exp(b(log x –log e))). Data were also subjected to ANOVA. In general the addition of clethodim to dicamba had a negative impact on Palmer amaranth control. However clethodim plus dicamba improved weed control for common lambsquarters. Our research further shows there is not an interaction between clethodim and dicamba. Our research also demonstrates the need to have a clear understanding of the response of the target species to tank-mixtures of clethodim and dicamba in order to make recommendations that will optimize the control of broadleaf weeds.

DEVELOPMENT OF CODOMINANT MARKERS FOR AMARANTHUS SPECIES IDENTIFICATION. Brent P. Murphy*, Patrick Tranel; University of Illinois, Urbana, IL (95)

The *Amaranthus* genus encompasses approximately 60 species, including the major agricultural weeds *A. tuberculatus* and *A. palmeri*. Few conserved morphological characteristics can differentiate between *Amaranthus* species, providing the necessity for molecular diagnostic techniques. A currently used diagnostic technique was developed in 1999 by Wetzel et al. based on 10 weedy *Amaranthus* spp. A polymorphic region of the ITS region was identified and a diagnostic enzyme digest array was developed across the tested species. The species array used in the development of this technique was constrained by two factors: biotypes specific to North America, and a focus on major weedy *Amaranthus* spp. Furthermore, enzyme digests prohibit the use of quantification of the level of presence of a fragment, preventing sample bulking and high-throughput analysis. The development of a quantitative PCR-based protocol would increase the throughput ability and ow for sample bulking. The establishment of conservation acres in high erosion-risk areas results in the movement of mixed seeds, potentiy between geographicy isolated regions. These regions can have unique *Amaranthus* spp, some of which can be considered noxious. The establishment of conservation acres potentiy provides a new mechanism of movement for weedy and noxious *Amaranthus* spp. The development of a high-throughput protocol to screen bulked samples would ow the identification of contaminated seed lots, and limit the risk of spread of these noxious species. A qPCR protocol for the identification of *A. palmeri* and *A. tuberculatus* was developed from sequence information of the ITS region. Primers were validated on 60 North American biotypes across five *Amaranthus* spp. Additional primer validation using 35 world-wide *Amaranthus* spp. biotypes, and numerous *A. palmeri* and *A. tuberculatus* biotypes was conducted. The potential for the development of additional techniques for species identification and quantification will be discussed.

RESPONSE OF NEBRASKA HORSEWEED (*CONYZA CANADENSIS*) POPULATIONS TO LACTOFEN AND CLORANSULAM-METHYL. Estefânia Gomiero Polli*, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (96)

The increased occurrence of herbicide-resistant biotypes in some weeds populations is a direct result of selection pressure generated by overreliance on herbicides in modern agriculture. Horseweed (*Conyza Canadensis*) is one of the most important weed species which has reported cases herbicides resistance. Glyphosate-resistant horseweed is widely distributed across Nebraska. However resistance to other herbicide modes-of-action are yet to be determined. The objective of this study was to investigate the level and frequency of herbicide resistance to lactofen and cloransulam-methyl in populations of horseweed in Nebraska. The study was conducted with a total of 94 populations of horseweed collected from 44 counties during the f of 2014 and 2015. Plants were grown under greenhouse conditions at the Pesticide Application Technology Laboratory in North Platte, NE. Rosettes four cm diameter were sprayed inside a single nozzle spray chamber using applicationspeed of seven km h^{-1} with a DG 9502EVS at 345 kPA pressure and positioned 0.38 m above the plant. Applications were made using 0.4 kg a.e. ha^{-1} for lactofen and 0.03 kg ha^{-1} for cloransulam-methyl. Visual estimates of plant injury were collected based on a scale of 0-100 (0 being no herbicidal effect and 100 complete control) at 7, 14, 21 and 28 d after treatment (DAT). Following evaluation of plant injury, plants were harvested and dried at 65 C for 7 d. The dry weight was recorded and data was analyzed using SAS (PROC GLIMMIX) to compare each population, for control. Results confirmed presence of 19 herbicide-resistant horseweed populations to lactofen and six to cloransulam-methyl.

ABILITY OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS*, CAUSAL AGENT OF GOSS'S WILT OF CORN, TO OVERWINTER IN ALTERNATIVE HOST DEBRIS AND SEED. Joseph T. Ikley*[1], William G. Johnson[2], Kiersten A. Wise[1]; [1]Purdue University, LAFAYETTE, IN, [2]Purdue University, West Lafayette, IN (97)

Goss's bacterial wilt and leaf blight of corn is caused by the bacterium *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). Goss's wilt has been identified in 17 states in the United States (U.S.) and has become an increasingly important disease over the last decade. Among corn diseases, Goss's wilt is currently the third-leading cause of yield loss in the U.S. and Canada, with an estimated loss of 13 million metric tons between 2012 and 2015. The cause of the recent reemergence and spread of the disease is unknown, but has been attributed to an increase in hectares planted corn-on-corn, an increase in no-tillage practices, and wide-spread use of corn hybrids that are susceptible to Cmn. Some grass weed species and cover crops have been documented as alternative hosts of Cmn, although their role as an additional source of inoculum has not been researched. To answer this question, two studies were initiated to research the potential of Cmn to overwinter on alternative hosts. In the first study, giant foxtail, large crabgrass, and a Cmn-susceptible corn hybrid were inoculated with a bacterial suspension containing 1 x 10^8 colony-forming units (CFU) of Cmn mL^{-1}. Plants with confirmed symptoms were buried in December 2013 in a field at the Agronomy Center for Research and Education near West Lafayette, Indiana at 0 and 10 cm below the surface. Plant debris was sampled every four months for two years to determine how long Cmn remains pathogenic in host plant tissue. Results from this study reveal that Cmn can overwinter and remain pathogenic on both corn and alternative host debris in Indiana for up to four months, but no pathogenic Cmn was recovered at or after the eight month sampling period. In the second study, annual ryegrass, giant foxtail, and johnsongrass were inoculated in the greenhouse with a bacterial suspension containing 1 x 10^8 CFU of Cmn mL^{-1} at three different growth stages: three-collar growth stage (V3) + six-collar growth stage (V6) + seed-head emergence, V6 + seed-head emergence, and seed-head emergence only. Plants were grown to maturity and seed were collected from plants. Seed were tested in the lab for the presence of Cmn inside the seed. Alternative hosts did not become systemicy infected, with symptomatic lesions never exceeding 65% on any inoculated leaf. Results from these studies indicate that Cmn can overwinter on infected host debris in Indiana, but the bacterium is not seed-borne in alternative hosts.

SURVEY OF FIELD PRACTICES, ENVIRONMENTAL FACTORS, AND ALTERNATIVE WEED HOSTS INFLUENCING THE OCCURRENCE OF GOSS'S WILT. Taylor M. Campbell*[1], Joseph T. Ikley[2], Kiersten A. Wise[2], William G. Johnson[3]; [1]Purdue University, Lafayette, IN,

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Goss's wilt is a bacterial disease in corn caused by *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). Goss's wilt was first discovered in 1969 in Dawson County Nebraska and today can be found in seventeen states and three provinces in Canada. The primary source of inoculum is infected corn debris that serves as an overwintering source for the bacteria. Continuous corn production and no-till systems are two cultural practices that leave large amounts of residue for Cmn to survive on. Pivot irrigation may also aid the spread of Cmn by wounding plants as the pivot moves through the field, splashing the bacteria onto lower portions of the plants, and moving infected debris. Known alternative hosts of Goss's wilt are johnsongrass (*Sorghum halepense*), shattercane (*Sorghum bicolor*), giant foxtail (*Setaria faberi*), green foxtail (*Setaria viridis*), yellow foxtail (*Setaria pumila*), bristly foxtail (*Setaria verticillata*), large crabgrass (*Digitaria sanguinalis*), and annual ryegrass (*Lolium multiflorum*). The objective of this study was to determine if selected field practices, environmental factors, or alternative weed hosts are commonly associated with the presence of Goss's wilt in Indiana. Fields with a history of Goss's wilt were visited periodicy throughout the summers of 2014, 2015, and 2016. The three most commonly observed weeds were giant foxtail, yellow foxtail, and large crabgrass. Gaint foxtail and yellow were found to have a relationship with the presence of Goss's wilt. Though none of the weeds were found to be expressing symptoms of Goss's wilt, producers should manage these weeds especiy in fields with a history of Goss's wilt, because they are confirmed alternative host and could serve as a "bridge" host for Goss's wilt in non-corn years. Corn hybrid and tillage were the only field practices found to have a relationship with the presence of Goss's wilt, and no environmental factors had a relationship with the presence of Goss's wilt. Out of the 35 surveyed fields 23 were planted to popcorn, which is commonly associated as being more susceptible to Goss's wilt. For this survey, fields planted to popcorn commonly used conventional-till and could have influenced the relationship between tilled fields and the occurrence of Goss's wilt. This implies fields planted to a more susceptible corn hybrid run a greater risk of influencing the occurrence of Goss's wilt. Producers dealing with Goss's wilt in Indiana should consider selecting corn hybrids tolerant to Goss's wilt and ensure alternative hosts are controlled along with using other cultural practices that can help reduce the inoculum potential of Cmn.

SEASONAL CHANGES IN FORAGE QUALITY OF COMMON PASTURE WEEDS IN MISSOURI. Zach L. Trower*[1], Mandy D. Bish[2], Meghan Biggs[1], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (99)

Grazing lands occupy approximately 33% of the total land use in the U.S. In Missouri, pastures account for approximately 526,000 hectares of land, and Missouri ranks 8th in the nation in beef cattle production. Weeds are the predominate pest in pastures, costing producers approximately two billion dollars annuy. The purpose of this research was to determine the seasonal changes in forage nutritive value of selected weed species that are commonly found in pasture environments. Weed species were collected from pastures located throughout Missouri during the 2015 and 2016 growing seasons. Weed species were collected at two-wk intervals beginning in mid-April and continuing through to mid- to late-September each year. The height and stage of each weed was recorded at the time of each sampling event. The weed species collected for analysis included horsenettle (*Solanum carolinense* L.), common ragweed (*Ambrosia artemisiifolia* L.), lanceleaf ragweed (*Ambrosia bidentata* Michx.), vervain (*Verbena spp*.), broomsedge (*Andropogon virginicus* L.), wooly croton (*Croton capitatus* Michx.), t ironweed (*Vernonia gigantea* Trel.), crabgrass (*Digitaria spp.),* serecia lespedeza (*Lespedeza cuneata* G.), yellow foxtail (*Setaria pumila),* spiny amaranth (*Amaranthus spinosus* L.), nutsedge (*Cyperus spp*.), smartweed (*Polygonum spp*), white snakeroot (*Ageratina altissima* L.), annual fleabane (*Erigeron annuus* L.), buckhorn plantain (*Plantago major* L.), nodding spurge (*Chamaesyce nutans*), dandelion (*Taraxacum officinale* F.H. Wigg.), common cocklebur (*Xanthium strumarium* L.), t goldenrod (*Solidago altissima* L.), annual lespedeza (*Kummerowia striata*), virginia copperleaf (*Acalypha virginica* L.), white sage (*Artemisia ludoviciana* Nutt.). A representative forage sample was harvested from each collection location at the time of each weed collection. Near-infrared spectroscopy was used to predict crude protein (CP) and in vitro true digestibility (IVTD) of weeds and forage samples. In 2015, forage quality of common ragweed, horsenettle, and lanceleaf ragweed decreased from the first collection at emergence to the final collection 20 wk later. Common ragweed and horsenettle, two of the most prevalent weeds in Missouri pastures, had crude protein percentages of 19.4 and 14.3, respectively, at the first collection date and 24.2 and 12.8 percent, respectively, at the final collection date. The IVTD for each were 94.1 and 86.6, respectively, at the first collection date. This is higher than the IVTD percentage of the representative forage samples at corresponding locations. IVTD percentages were 75.6 for common ragweed and 67.2 for horsenettle at the final collection date. Dandelion had a CP percentage of 24.3 and an IVTD percentage of 96 at the first collection date. Both CP and IVTD percentages of dandelion at 11 out of 12 collection dates exceeded those of the representative forage samples. This data will be used to determine the impact of specific weed species and their effect on over forage quality in pasture systems.

WELCOME TO IOWA. Bill Northey*; Iowa Department of Agriculture and Land Stewardship, Des Moines, IA (100)

BRIDGING TO BETTER TIMES. Dermot J. Hayes*; Iowa State University, Ames, IA (101)

The presentation will begin with an analysis of the financial stresses faced by corn and soybean growers with an emphasis on those who rent land. It will describe how they are dealing with this stress and how some input prices have adjusted. It will also describe how much additional adjustment in cash rents is needed. The next section will evaluate the risk management strategies that are in use and offer some judgements on how hedging practices could be improved. The third part of the presentation will focus on trade agreements and will include a discussion on why the author is optimistic about the long run prospects for these agreements despite the current political climate. Opportunities for exports to Japan and Vietnam under TPP will be analyzed. The fourth part of the presentation will focus exclusively on China and describe recent changes in Chinese corn policy and trends in value added exports. This portion of the presentation will provide room for optimism once the current glut in the world corn market has been eliminated The final part of the presentation will use a simple game to show how industry concentration leads to higher prices even when firms are obeying antirust regulations.

WASHINGTON DC REPORT. Lee Van Wychen*; National and Regional Weed Science Societies, Alexandria, VA (102)

NCWSS PRESIDENTIAL ADDRESS. Anita Dille*; Kansas State University, Manhattan, KS (103)

REMEMBERING FORMER NCWSS MEMBERS AND FRIENDS. Aaron G. Hager*; University of Illinois, Urbana, IL (104)

ANNOUNCEMENTS. Gregory K. Dahl*; Winfield United, River Fs, WI (105)

SURVEY OF NEBRASKA SOYBEAN PRODUCERS: AGRONOMIC PRACTICES AND WEED MANAGEMENT STRATEGIES. Rodrigo Werle*[1], Joshua J. Miller[2]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska - Lincoln, LINCOLN, NE (106)

A survey was conducted with 290 growers and agronomists during the 2016 Soybean Management and Water and Crops Field D across five soybean production areas of Nebraska. The objective was to understand common cultural practices adopted by Nebraska soybean growers such as irrigation, tillage method, row spacing, and seeding rate, as well as their perception on the current and future status of weed management. Results of the weed management related questions will be presented herein. Among participants, 94% reported the presence of glyphosate-resistant (GR) weeds in their operations. Common waterhemp (69%) and horseweed (69%) appeared as the most common GR species followed by Palmer amaranth (21%), giant ragweed (7%) and kochia (7%), respectively. Moreover, 70% of participants reported to have two or more GR species present in their operations. When asked about resistance to additional modes of action (MOA), resistance to ALS, HPPD, and triazine were reported by growers and some noted unsatisfactory weed response to PPO and auxinic herbicides. 89% of participants reported the use of soil residual herbicides and 76% reported the use of multiple MOA at each application, which are common recommendations for herbicide-resistance management. 24% reported adoption of f herbicide application. Horseweed was ranked as one of the most troublesome weeds in soybeans in Nebraska and a f herbicide application could be a useful strategy to manage this winter annual weed. When asked about new technologies for weed management, specificy dicamba-, 2,4-D-, HPPD- and ALS-tolerant soybeans, 91% of respondents indicated they are likely to adopt these technologies, but varied greatly on whether weed resistance would increase (40%), not change (23%), or decrease (37%). Regarding cultural practices/alternative strategies for weed management, inter-row cultivation and narrow-row spacing (<76 cm) are not widely adopted. 33% reported the adoption of cover-crops, mainly for erosion control and cattle feed; however, several participants showed the interest in cover crops as a potential weed management tool. Therefore, narrow-row spacing, inter-row cultivation and inclusion of cover crops are alternative strategies that could be further explored by growers as weed management tools. The implications of our survey and additional strategies that growers are considering will be discussed.

HOW 80 YEARS OF SOYBEAN BREEDING HAS AFFECTED COMPETITIVENESS WITH WEEDS. Devin J. Hammer*, Shawn P. Conley, David E. Stoltenberg; University of Wisconsin-Madison, Madison, WI (107)

Soybean yield gain over the last century has been attributed to both genetic and agronomic improvements over time. Recent research has characterized how breeding efforts to improve yield gain have also secondarily impacted agronomic decisions such as seeding rate, planting date, and fungicide use. However, no research has characterized the relationship between weed-crop interference and genetic yield gain. Therefore, the objective of this research was to determine if soybean breeding efforts over time have indirectly affected crop competitiveness. This study was conducted in 2014, 2015 and 2016 at the University of Wisconsin Arlington Agricultural Research Station. The experimental design was a randomized complete block in a split-plot arrangement with three replications. The whole plot factor was three seeding rates (0, 2.8, and 11.2 seeds m^{-2}) of our model weed species, volunteer corn. Volunteer corn was selected due to its high level of competitiveness and regular occurrence in Midwest soybean fields. The sub-plot factor consisted of 40 maturity group II soybean varieties released from 1928 to 2013. In 2015 and 2016, soybean and volunteer corn height and width data were collected from three plants $plot^{-1}$ to characterize plant growth. Above-ground dry shoot biomass was determined for three corn plants at R8 soybean. Soybean seed yield was harvested by machine from each plot in each year. Because soybean samples contained both volunteer corn and soybean seed, subsamples were taken and sorted to quantify the percentage of soybean and volunteer corn seed yield by mass for each plot In 2014 and 2015 soybean seed yield increased linearly 16.0 kg ha^{-1} yr^{-1} over cultivar release year in a competition-free environment ($P < 0.001$.) Regression analysis indicated that cultivar release year had no effect on volunteer corn shoot biomass at either seeding rate of 2.8 or 11.2 seeds m^{-2}. Preliminary analysis suggests that newer varieties of soybeans yield higher than older varieties under moderate and high levels of weed competition.

CHENGING WEEDS USING ORGANIC PRACTICES IN SOYBEAN (GLYCINE MAX). Ricardo Costa*, Kerry Clark, Reid Smeda; University of Missouri, Columbia, MO (108)

Weed management is a major problem limiting production of organic soybeans. Tillage is the most dominant weed control practice, but sustainable production must encompass other methods. This research is part of a multi-year study to compare tillage, flame cultivation, mowing, and hot water (mowing and hot water followed a cover crop) for in-season weed control in soybeans. In central Missouri, an organic, conventiony certified area was tilled and planted in the f of 2015, with predominantly rye cover as a crop. The following spring, rye growth was terminated at Zadoks 61 stage by crimping and other areas tilled to eliminate rye residues. Soybeans were planted at 77,900 plants ha^{-1} where rye was previous crimped and at 66,770 plants ha^{-1} in tilled plots. As weeds initiy reached 10 cm, control practices were implemented and repeated on the same plots from three to eight times until canopy closure. Weed density between rows and plant biomass by species were recorded throughout the season. Thirty-three d after planting (DAP), grass (giant foxtail, *Setaria faberi* and, large crabgrass, *Digitaria sanguinalis*) biomass in flame cultivated areas was two-fold higher compared to mechanicy cultivated plots, and 5.7-fold higher than mowed areas. Because of weed suppression by rye in crimped areas, there was no need to initiate application of hot water because no weeds were found. Biomass of broadleaf weeds (waterhemp, *Amaranthus rudis* and field bindweed, *Convolvulus arvensis*) was highest in the mechanical cultivation treatment, 3.3-fold higher than flame cultivation, and 4.8-fold higher than mowing. At 60 DAP, grass biomass in the hot water treatment was 3.7-fold compared to mechanicy cultivated areas and 2.8-fold higher than flame cultivated areas. Between-row mowing was not used at this time because plots remained free of weeds. Biomass of broadleaf weeds was highest where hot water was used; 22.8 and 3.3-fold higher than mechanical cultivation and flame cultivation, respectively. By 87 DAP, soybean height precluded further use of flame cultivation. Between-row mowing remained suitable for continued use. At the end of the season, in-row weed and between-row weed biomass was estimated. Mowed plots had the least amount of weeds compared to the other treatments, 29 and 22% less biomass of in-row weeds than plots where hot water and mechanical cultivation were performed. Among treatments, the order from greatest to least weed biomass (between rows) was: hot water >flame cultivation > mechanical cultivation > mowing. Flame cultivation can result in soybean injury, opening up the crop canopy and permitting weed encroachment if not limited for use on larger soybeans. Excessive rainf precluded the effectiveness of mechanical cultivation, as grasses re-rooted and continued to develop. Hot water offers some promise to reduce weed biomass, but thorough coverage of treated plants is critical. Effective control of weeds growing within the crop remains a major chenge.

HERBICIDE AND TIMING OPTIONS FOR RESIDUAL AND BURNDOWN CONTROL OF PIGWEED (*AMARANTHUS SPP*) FOR DOUBLE CROP SOYBEAN. Marsh M. Hay*, Das E. Peterson, Douglas E. Shoup; Kansas State University, Manhattan, KS (109)

Double crop soybean after wheat is a component of many cropping systems across eastern and central Kansas. Until recently, weed control of *pigweed*, particularly Palmer amaranth and t waterhemp, has been both easy and economical through the use of sequential applications of glyphosate in glyphosate-tolerant soybean. Due to this management approach, many populations of Palmer amaranth and t waterhemp in Kansas have become resistant to common use rates of glyphosate, which cs for a change in management. During 2015 and 2016, five site years of research were implemented at experiment fields near Manhattan, Hutchinson, and Ottawa, Kansas to assess various non-glyphosate herbicide programs at three different application timings for control of Palmer amaranth and t waterhemp in a double crop soybean after winter wheat cropping system. Emergence of Palmer amaranth and t waterhemp begins in April in southern Kansas. Therefore, spring-post (SP) treatments of pyroxasulfone and pendimethalin were applied to wheat at Feekes 4 to evaluate residual control of Palmer amaranth and t waterhemp ahead of double crop soybean; however, at sites after wheat harvest, less than 50% control of Palmer amaranth and t waterhemp was observed in the SP treatments. Two-week pre-harvest (PH) treatments of 2,4-D LV-4 and flumioxazin were also applied to the wheat to assess burndown control of emerged Palmer amaranth and t waterhemp in the wheat crop. These treatments resulted in highly variable control at sites. Wheat harvest, no-till soybean planting, and preemerge (PRE) herbicide treatments occurred within 24 hr at locations. Excellent control was observed at one wk after planting (WAP) with a PRE paraquat application. Reduced control of Palmer amaranth and t waterhemp was noted at 8 WAP due to extended emergence. Palmer amaranth and t waterhemp control was 85% or greater at 8 WAP for most PRE treatments that included a combination of paraquat plus residual herbicides. PRE treatments that did not include paraquat or residual herbicides did not provide acceptable control.

EVALUATION OF 2,4-D, DICAMBA, GLYPHOSATE, AND HALAUXIFEN-METHYL TANK-MIXTURES ON BROADLEAF WEEDS. Marcelo Zimmer*[1], Bryan Young[1], William G. Johnson[2]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN (110)

Evolution of glyphosate-resistant (GR) broadleaf weeds is a major concern for sustainable for corn and soybean production in the U.S. Synthetic auxin herbicides are commonly used in preplant burndown applications to control broadleaf weeds. Halauxifen-methyl is a new synthetic auxin active ingredient, highly effective at controlling horseweed at low use rates (5 g a.e. ha^{-1}). The hypothesis was tank-mixtures would increase weed control spectrum of halauxifen-methyl applications on broadleaf weeds when horseweed infestation is the major issue. Experiments were conducted in 2015 and 2016 at three locations in Indiana. Each site was infested with different problematic broadleaf weed species, including GR horseweed (*Conyza canadensis* L.), GR giant ragweed (*Ambrosia trifida*), common ragweed (*Ambrosia artemisiifolia*), and redroot pigweed (*Amaranthus retroflexus*). Treatments consisted of tank-mixtures of halauxifen-methyl with 0.5 X rates of 2,4-D, dicamba, and glyphosate. Data collection consisted of visual estimates of weed control, weed density counts, and pictures for analysis with ImageJ imaging system. Halauxifen-methyl applied alone or in tank-mixtures provided 87 to 97% visual control of GR horseweed, and 91 to 97% visual control for common ragweed. Giant ragweed and redroot pigweed were not adequately controlled when halauxifen-methyl was applied alone, resulting in 65 and 50% control, respectively. However, when halauxifen-methyl was applied in tank-mixtures greater control was observed, ranging from 69 to 92% for giant ragweed and from 74 to 94% for redroot pigweed. In conclusion, halauxifen-methyl controls GR horseweed and common ragweed at the labeled rate. Tank-mixtures of halauxifen-methyl with 2,4-D and dicamba increased visual estimations ofcontrol of GR giant ragweed and redroot pigweed.

DOES SPEED OF ACTIVITY TRANSLATE TO FINAL EFFICACY FOR PARAQUAT APPLICATIONS? Garth W. Duncan*[1], Julie M. Young[2], Bryan Young[2]; [1]Purdue University, Lafayette, IN, [2]Purdue University, West Lafayette, IN (111)

Paraquat is commonly used as a preplant burndown herbicide prior to corn or soybean planting for control of problematic winter annual weeds, including glyphosate-resistant horseweed (*Conyza canadensis*). Applications of paraquat can lead to inconsistent efficacy largely attributed to the specific conditions associated with the herbicide application. An objective of this research was to determine if this variability in final efficacy is related to the speed at which visual symptoms develop from paraquat. Greenhouse experiments were conducted to determine the relative efficacy and speed of symptomology for paraquat on select problematic weed species (Palmer amaranth, waterhemp, giant ragweed, horseweed, and purple deadnettle). Treatments included nine rates of paraquat (0, 1.10, 2.19, 4.38, 8.75, 17.5, 35, 70, 140 g a.i. ha-1) with nonionic surfactant (NIS) at 0.25% v v^{-1} applied at 7:30 am on a day with full sun. Visual ratings were taken at two HAT and continued every two hours until 12 HAT to capture the first sign of visual symptoms. Sensitivity to paraquat was evaluated using a log-logistic model to determine the rate providing 50% growth reduction (GR_{50}). Palmer amaranth and waterhemp were the most susceptible species to paraquat with GR_{50} values of 11 and 8.4 g ha^{-1}, respectively. Giant ragweed, horseweed, and purple deadnettle were less susceptible to paraquat with GR_{50} values of 21, 30, and 39 g ha^{-1}, respectively. Symptomology from the 70 g ha 1 of paraquat evaluated was first observed at two HAT in Palmer amaranth, waterhemp, and giant ragweed, four HAT in purple deadnettle, and six HAT in horseweed. At 17.5 g ha^{-1}, this trend continued with waterhemp and Palmer amaranth showing visual symptoms at four HAT, giant ragweed at six HAT, and purple deadnettle and horseweed at 12 HAT. Further greenhouse experiments were conducted to determine the relationship of adjuvants, air temperature, light intensity, and application time of day on the speed of paraquat activity on these same five weed species. In most cases, slower initial activity did not improve or impede final efficacy. Only in one instance, waterhemp under low light conditions, it was observed that reduced initial symptomology provided greater final efficacy. Additiony, purple deadnettle applied later in the day and purple deadnettle and horseweed applied under cool temperatures reduced initial symptomology and provided less final efficacy. Thus, the extent of final paraquat efficacy was associated with both relatively fast and slower initial plant response to paraquat. Field trials were conducted in 2014 and 2015 to investigate the influence of application time of day for paraquat or the addition of metribuzin on over efficacy on horseweed. In 2014, at one d after treatment (DAT), 15 to 20 cm horseweed plants treated with a tank-mixture of paraquat + metribuzin on showed less visual injury (17 to 38%) than plants treated with paraquat alone (61 to 66%) across both application times of day. By three DAT, both paraquat and paraquat + metribuzin treated plants were equal in visual control (77 vs 76% at solar noon and 74 vs 73% at sunset). By 28 DAT, horseweed plants sprayed with the tank-mixture provided greater control (98% dry weight growth reduction) versus paraquat applied alone (70 to 87% growth reduction). In 2015, the paraquat + metribuzin tank-mixture provided less visual control at one DAT compared to paraquat alone (47 to 48% vs 73 to 86%). By 28 DAT, greater than 93% control was achieved with paraquat or paraquat + metribuzin regardless of application time of day. Based on this research, the reduction in the speed of symptom development from the tank-mixture of paraquat plus metribuzin did result in the greatest level of final herbicide efficacy on horseweed. When applying paraquat alone a slower response for the development of initial plant injury symptoms did not translate to the greatest extent of final paraquat efficacy. In general, faster development of injury symptoms from paraquat associated with the greatest final efficacy on winter annual weed species.

PREPLANT BURNDOWN HERBICIDE OPTIONS FOR CONTROL OF GLYPHOSATE-RESISTANT COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L) IN GLUFOSINATE-RESISTANT SOYBEAN. Ethann Barnes*[1], Peter H. Sikkema[2], Stevan Knezevic[3], John Lindquist[4], Amit Jhala[5]; [1]University of Nebraska- Lincoln, Lincoln, NE, [2]University of Guelph, Ridgetown, ON, [3]University of Nebraska-Lincoln, Concord, NE, [4]University of Nebraska-Lincoln, Lincoln, NE, [5]University of Nebraska Lincoln, Lincoln, NE (112)

Common ragweed emerges early in the season in Nebraska and is highly competitive with soybean; therefore, effective preplant herbicides are important. Confirmation of glyphosate-resistant (GR) common ragweed in Nebraska necessitates additional tools for control. Glufosinate is an alternative herbicide option for controlling GR weeds in glufosinate-resistant soybean. A field experiment was conducted on a grower's field infested with GR common ragweed in Gage County, NE in 2015 and 2016. The objective was to evaluate the efficacy of preplant herbicides followed by glufosinate applied alone or in tank-mixture for control of GR common ragweed in glufosinate-resistant soybean. Preplant treatments containing glufosinate, paraquat, 2,4-D, dimethenamid-P, cloransulam-methyl, or high rates of flumioxazin plus chlorimuron ethyl provided 90 to 99% control of common ragweed 21 DAT. Glufosinate applied alone or in tank-mixture with ALS or long-chain fatty acid inhibitors early or late POST provided ≥ 91% control at 14 DAT. Effective preplant herbicides with ≥ 90% control of common ragweed 21 DAT, followed by a POST application of glufosinate alone or in tank-mixture resulted in season-long control (≥ 84%), reduced common ragweed density (≤ 20 plants m^{-2}) and biomass by ≥ 70%). Preplant followed by POST treatments resulted in the highest soybean yields (≥ 1819 kg $ha^{-1)}$). The results of this study indicated that preplant herbicide use is critical for common ragweed control and suggested that glufosinate alone or in tank-mixture is a valuable tool for the control of GR common ragweed in glufosinate-resistant soybean.

EFFECTS OF SIMULATED TANK-CONTAMINATION WITH 2,4-D AND DICAMBA ON SUGARBEET. Michael A. Probst*, Christy L. Sprague; Michigan State University, East Lansing, MI (113)

The release of dicamba- and 2,4-D-resistant soybean will provide growers with additional tools for selective broadleaf weed control in soybean. However, the use of these new technologies will lead to an increased potential for the occurrence of tank contamination with dicamba and 2,4-D and the subsequent application to sensitive crops. This is of great concern to Michigan sugarbeet farmers, as exposure to these herbicides can be detrimental to their crops and possibly result in the condemnation of entire fields. To evaluate the effects that dicamba and 2,4-D have on the growth and quality of sugarbeet, field studies were conducted at the Michigan State University Agronomy Farm in East Lansing, MI, and the Saginaw Vey Research and Extension Center in Richville, MI. To simulate tank contamination at both locations, sugarbeets were sprayed at the two-leaf stage with six rates ranging from 0.0625-1% of the field use rate and at the pre-canopy stage with six rates ranging from 0.125-2% of the field use rates. The field use rate for dicamba and 2,4-D was 1.12 kg a.e. ha^{-1} and 1.10 kg a.e. ha^{-1}, respectively. At the Richville location, an additional application timing was included when sugarbeets were at the six-leaf stage with six rates ranging from 0.125-2% of the field use rates. Treatments included 0.84 kg a.e. ha^{-1} of glyphosate and were compared with a glyphosate only control. Herbicide injury was evaluated at 7, 14, and 21 d after treatment (DAT), and beet yield and sugar quality were measured at harvest. As expected, the highest rates of both 2,4-D and dicamba showed the most signs of herbicide injury at timings, with maximum injury ratings of 40% for dicamba and 42% for 2,4-D. Occurrence of injury symptoms differed between the two herbicides, with beets receiving dicamba treatments typicy showing the most injury seven DAT while beets receiving 2,4-D treatments often showed the most injury either 14 or 21 DAT. Timing of herbicide application did not appear to have an effect on herbicide injury; however, timing did appear to have an effect on sugarbeet yield, with later applications resulting in lower yields, especiy at higher rates. In East Lansing, the high rates at the pre-canopy stage resulted in a 7% and 21% yield reduction from dicamba and 2,4-D, respectively. These differences most likely resulted from the amount of recovery time associated with each timing. Neither rate nor timing seemed to have an effect on the percent sugar content, while low yields were typicy associated with low recoverable white sugar per hectare amounts. The misapplication of dicamba and 2,4-D on sugarbeets has the potential to result in serious injury as well as a loss of yield and recoverable white sugar.

COMPARISON OF SINGLE AND MULTIPLE SITES OF HERBICIDE ACTIVITY ON A MIXED POPULATION OF HERBICIDE RESISTANT PALMER AMARANTH AND WATERHEMP. Nick Fleitz*[1], JD Green[2], James R. Martin[3], Patrick Tranel[4]; [1]Graduate Student, Lexington, KY, [2]University of Kentucky, Lexington, KY, [3]University of Kentucky, Princeton, KY, [4]University of Illinois, Urbana, IL (114)

Herbicide-resistant Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*) are introduced weed species that pose threats to Kentucky grain crops. Confirmed populations of Palmer amaranth in half the counties and waterhemp in one third of the counties in Kentucky signify the continued spread of these weed species across the state. A field experiment was conducted in 2016 on a fow site containing a mixed population of glyphosate- and PPO-inhibitor- resistant Palmer amaranth and waterhemp. The objectives for this study included the comparison of pre-emergent (PRE) soil residual applications with post emergent (POST) and PRE/POST combinations and to compare single vs. multiple sites of herbicide activity. Treatments included POST applications only, PRE applications only and PRE/POST emergent combinations which contained from one to four herbicide site-of-action groups. Thirty-two treatment combinations were arranged in a randomized complete block design with three replications. Percent visual control, effects on plant density and plant height were measured to determine treatment efficacy of these Amaranthus species. Within the long-chain fatty acid inhibitor herbicides in this study, PRE applied pyroxasulfone (178 g a.i. ha^{-1}) provided greater control than S-metolachlor (1792 g a.i. ha^{-1}) or acetochlor (1817 g a.i. ha^{-1}). Pyroxasulfone (178 g a.i. ha^{-1}) also provided greater control than the photosystem II herbicides atrazine (1680 g a.i. ha^{-1}) and metribuzin (426 g a.i. ha^{-1}). Combinations of either S-metolachlor + metribuzin (2206 + 526 g a.i. ha^{-1}) or S-metolachlor + metribuzin + fomesafen (2128 + 470 + 426 g a.i. ha^{-1}) applied PRE, followed by post application of glufosinate (650 g a.i. ha^{-1}) + acetochlor (1817 g a.i. ha^{-1}) provided 98% control. Dicamba (560 g a.e. ha^{-1}) or 2,4-D (1120 g a.i. ha^{-1}) alone, or in pre-mixture with glyphosate provided 67 to 78% control of this mixed Amaranthus population. Treatments containing four different sites of herbicide activity achieved an average of 98% control and treatments containing three sites of herbicide activity achieved an average of 64% control. Treatments with only one or two sites of herbicide activity resulted in an average control of 33 and 45% control, respectively. Soil residual treatments applied PRE only averaged 29% control, while POST only treatments averaged 62% control. Combination PRE/POST treatments achieved an average of 77% visual control. Amaranthus plant density was also reduced by applying treatments with three and four sites of activity compared to only one site of activity. Measurement of plant height indicated that treatments with three and four sites of herbicide activity were superior to treatments with only one site of activity.

DRY BEAN AND SUGARBEET RESPONSE TO BICYCLOPYRONE RESIDUES. Daniel D. Wilkinson*, Christy L. Sprague; Michigan State University, East Lansing, MI (115)

Bicyclopyrone is one of the newest HPPD-inhibiting herbicides (Group 27) registered for use in corn. It is currently a component of several pre-mixtures that can be applied PRE or POST. However, new uses could result in the product being applied alone in corn or other crops. Currently, there is very little data available on the carryover potential of bicyclopyrone to two of Michigan's agronomic specialty crops. Based on this data gap the objectives of this research were to: 1) evaluate the carryover potential of bicyclopyrone to two classes of dry edible beans (kidney and black beans) and sugarbeets, and 2) compare the potential carryover effects from bicyclopyrone to mesotrione in these crops. The current rotation restriction for dry edible beans and sugarbeet for mesotrione is 18 months. In 2015, a field experiment was established at two locations. The experiments were conducted in East Lansing, MI on a loam soil with a pH of 6.0 and organic matter of 4.5% and in Richville, MI on a clay loam soil with a pH of 7.8 and organic matter 2.6%. The experiment was setup as a split plot design with four replications. The main plots were the herbicide treatments: bicyclopyrone applied at 50 and 100 g a.i. ha^{-1} (1X and 2X), mesotrione applied at 210 g a.i. ha^{-1}, and a nontreated control. These treatments were applied POST to corn in early June at the V3 growth stage in the first year of the experiment. Corn was removed as silage in early September. In the spring 2016, 'Crystal 059' sugarbeets were planted in mid-April and 'Zorro' black beans and 'Red Hawk' kidney beans were planted in mid-June. Minimum tillage with a show soil-finishing tool was done prior to planting. Stand counts were taken seven and 21 d after emergence and crops were evaluated bi-weekly for injury throughout the growing season. Dry beans and sugarbeet were harvested at the end of the growing season. Regardless of herbicide treatment and rate, there was very little injury to sugarbeet and dry bean from applications of bicyclopyrone or mesotrione compared with the untreated control. Warmer than normal temperatures and high amounts of rainf may have contributed to the lack of injury observed from mesotrione and possibly bicyclopyrone. These experiments will be repeated in the spring of 2017. Further research is needed on the relative sensitivity of these crops to bicyclopyrone and mesotrione.

INTERACTION OF SOIL RESIDUAL PPO-INHIBITING HERBICIDES AND S-METOLACHLOR ON SELECTION OF PPO-RESISTANT WATERHEMP. Brent C. Mansfield*, Haozhen Nie, Bryan Young; Purdue University, West Lafayette, IN (116)

The use of protoporphyrinogen oxidase (PPO)-inhibiting herbicides in soybean production has increased dramaticy in recent years to manage t waterhemp (*Amaranthus tuberculatus* syn. *rudis*) populations with resistance to glyphosate. An increase in PPO-herbicide use continues to be disconcerting because of the consequential increase in selection pressure for PPO-resistant biotypes. Previous research has demonstrated that the use of soil residual PPO-inhibiting herbicides, including fomesafen, can increase the frequency of the PPO resistance trait (ΔG210 deletion) in the t waterhemp plants that escape the residual herbicide. In addition, combining *s*-metolachlor as an alternative site-of-action with fomesafen did not affect this increase in the PPO resistance trait when the rate of the two herbicides were applied at a constant ratio. A hypothesis was formed that the length of effective soil residual activity of the alternate herbicide site-of-action relative to the length of soil residual from fomesafen will influence the frequency of the PPO resistance trait in the surviving weed population. A field experiment was conducted to investigate this hypothesis on a population of t waterhemp with a frequency of the PPO resistance trait in approximately 2% of the emerging waterhemp plants. Herbicide treatments included a factorial of three rates each of fomesafen (0, 66, 132, 264 g a.i. ha^{-1}) and *s*-metolachlor (0, 335, 710, 1420 g ai ha^{-1}) applied preemergence to a weed-free, stale seedbed. The first 25 waterhemp plants to emerge (i.e. escape) after treatment were collected for genotypic analysis to determine the ratio of resistant and susceptible plants. Number of waterhemp plants collected 28 d after treatment (DAT) varied ly with some treatments having zero emergence. The frequency of the PPO resistance trait in the surviving t waterhemp plants increased with an increase in the application rate of fomesafen. The addition of *s*-metolachlor to fomesafen markedly reduced the number of t waterhemp individuals surviving the soil residual herbicide application and would be a component of best management practices for mitigating t waterhemp resistance to PPO-inhibiting herbicides.

INVESTIGATING THE POTENTIAL EFFECTS OF PRE-EMERGENCE RESIDUAL HERBICIDES AND SEED TREATMENT IN SOYBEAN . Blake R. Barlow*, Meghan Biggs, Mandy Bish, Kevin Bradley; University of Missouri, Columbia, MO (117)

Earlier planting in combination with the greater adoption of pre-emergent (PRE) residual herbicides has led to an increase in the reported incidences of early-season soybean injury in recent years. During this same time period, the percentage of soybean treated with seed treatments has grown substantiy. Field experiments were conducted over two years in Missouri to determine if early-season soybean injury correlates with yield loss and whether interactions exist between commonly used PRE herbicides and seed treatments. The experiments were conducted in a randomized complete block design with factorial arrangement of varieties, seed treatments, and herbicides. Treatments were replicated five times in 2015 and six times in 2016. Both trials were kept weed-free throughout the growing season. Each herbicide and seed treatment combination was evaluated across two geneticy similar soybean varieties, one with known tolerance to PPO-inhibiting herbicides and one with known sensitivity. The three seed treatments evaluated include imidacloprid (Gaucho), pasteuria nishizawae (Clariva) plus thiamethoxam (Cruiser), and fluopyram (ILeVO) plus imidacloprid (Gaucho). Each seed treatment also contained a common proprietary base treatment blend of insecticides, fungicides, and biologicals. A no seed-treatment control was included for each variety. Three herbicides were tested across each variety and seed-treatment combination. In both years, chlorimuron-ethyl plus flumioxazin plus metribuzin, chlorimuron-ethyl plus flumioxazin plus pyroxasulfone, and chlorimuron-ethyl plus sulfentrazone were each applied PRE at twice the labeled use rate (2X) and also applied at the labeled rate (1X) in 2016. A non-treated herbicide control was included for comparison each year. Soybean stand counts, height, and biomass measurements were recorded 10 and 30 d after emergence (DAE), and yield was determined at the end of the season. Across both years, seed treatments affected yield. Chlorimuron-ethyl plus sulfentrazone reduced yield more in the PPO-sensitive variety compared to the PPO-tolerant variety across both years, with 67% yield loss in 2015 and 38% in 2016. Chlorimuron-ethyl plus flumioxazin plus metribuzin reduced yield of the sensitive variety by 13% in 2015 only, while chlorimuron-ethyl plus flumioxazin plus pyroxasulfone reduced yield by 8% in 2016 only. There were also interactions between variety and herbicide treatment for the variables measured except soybean biomass in 2015. Results of this two-year study suggest few interactions between PRE residual herbicides and seed treatments, but injury from PRE residual herbicides is highly dependent on soybean variety.

INTEGRATING SOYBEAN ROW WIDTH AND A CEREAL RYE COVER CROP TO MANAGE GLYPHOSATE-RESISTANT PALMER AMARANTH.
Kelsey M. Rogers*[1], Christy L. Sprague[2], Karen A. Renner[2]; [1]Michigan State University, Lansing, MI, [2]Michigan State University, East Lansing, MI (118)

Herbicide-resistant Palmer amaranth continues to be a threat to Michigan field crop growers. In addition to herbicide-resistance issues, Palmer amaranth's ability to emerge throughout the growing season and its rapid growth rate makes it extremely difficult to manage with herbicides alone. One potential approach to improve management of herbicide-resistant Palmer amaranth in soybean is to incorporate the use of additional cultural practices, such as narrow row widths and cover crops. A field experiment was established in the f of 2014 and 2015 near Middleton, Michigan in a field with a confirmed glyphosate-resistant Palmer amaranth population. The objectives of this research were to examine the effects of: 1) a cereal rye cover crop, 2) cover crop termination method, 3) soybean row width and 4) herbicide programs on Palmer amaranth management and soybean yield. The experiment was a split-split-plot design with the main plots: 1) cereal rye cover crop terminated in the spring with flail mowing, 2) cereal rye cover crop terminated in the spring with glyphosate, and 3) no cereal rye cover. The sub-plots were soybean planted in two different row widths: 19 cm and 76 cm rows. The sub-sub-plots included three different Palmer amaranth management strategies: no management, low management strategy (flumioxazin PRE fb. glufosinate POST), and high management strategy (flumioxazin PRE fb. glufosinate + acetochlor POST). Each plot was replicated four times. Cereal rye biomass averaged 120 g m^{-2} of dry biomass (1200 kg ha^{-1}) in 2015 and 218 g m^{-2} of dry biomass (2186 kg ha^{-1}) in 2016 which suppressed winter annual and early summer annual weed biomass 77% and 84%, respectively, compared with the no cover control at the time of rye termination. Cereal rye was not controlled by flail mowing in either year and produced an additional 128 g m^{-2} and 58 g m^{-2}, respectively, of dry biomass before being terminated by glyphosate prior to soybean planting. Over, the cereal rye cover crop and termination method had minimal effects on Palmer amaranth control in both years. Palmer amaranth emergence began June 16 in 2015 and June 7 in 2016, 33 and 27 d, respectively, after cereal rye termination. In 2015, Palmer amaranth was controlled in both the low and high Palmer amaranth management systems; however, a lack of precipitation in 2016 resulted in poor control in the low management system. Soybean canopy closure occurred at least two wk earlier in the 19 cm row width compared to the 76 cm row width in both years. Soybean yield in the low and high management systems in 2015 were greater compared with the no management treatments, while in 2016 soybean yield was 624 kg ha^{-1} higher in the high management compared with the low management system. Low cereal rye biomass at the time of termination (late-April/early-May) may limit Palmer amaranth suppression in Michigan because of later emergence. The use of a residual preemergence herbicide followed by a post-emergence application is the most effective treatment in controlling Palmer amaranth, regardless of row spacing.

THE INFLUENCE OF APPLICATION SPEED AND PRESSURE ON WEED CONTROL.
André de Oliveira Rodrigues*[1], Lucas Giorgianni Campos[2], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (119)

Improper or sub-optimal application techniques can cause decreases in weed control and increase environmental contamination. There is a need for research to investigate how sprayer speed and pressure contribute to the optimization of the application process. The objective of this study was to evaluate the influence of sprayer speed and pressure on weed control. A greenhouse study was conducted at the UNL-WCREC in North Platte NE on the following weed species: velvetleaf (*Abutilon theophrasti Medik),* common waterhemp (*Amaranthus rudis Sauer)*, kochia (*Kochia scoparia (L.) Schrad),* horseweed (*Conyza Canadensis (L.) Cronq.),* common lambsquarters (*Chenopodium album L.)* and grain sorghum (*Sorghum bicolor (L.) Moencch subsp. Bicolor).* Two herbicides (dicamba 0.56 kg a.e. ha^{-1} and glyphosate 0.77 kg a.e. ha^{-1}) were tested separately and in a tank-mixtures. Applications were made when weed species were 10 to 15 cm t and were sprayed with 94 l ha^{-1} at three different speeds 8, 16, and 24 kph. Application pressures used were 124, 207, 276, 345, 482, and 517 kPa and were appropriately matched with the speed treatment to provide a constant carrier volume of 94 l ha^{-1}. The nozzles used were XR, AIXR, and TTI nozzles with orifice sizes ranging from 015 to 06, which generated droplet size classifications from fine to ultra-coarse depending on the combination used. These combinations resulted in an unbalanced treatment design with a total of 81 treatments for each weed species. Plants were sprayed with a three nozzle track sprayer with nozzles spaced 50 cm apart and plants located 50 cm from the nozzles during application. After plants were treated, visual estimations of injury were collected at 7, 14, 21, and 28 d after application (DAA). At 28 DAA plants were clipped at the soil surface, wet weights were recorded, plants were dried to constant mass, and dry weights were recorded. The set of application combining the TTI 11005 nozzle, with 276 kPa and 24 kph provided the most unsatisfactory control with a range of control from 32 to 75% for common waterhemp and common lambsquarters, in the other hand the set of application combining the AIXR11004 nozzle, with 207 kPa and 16 kph provided the most satisfactory control with a range of control from 91 to 100% control on common waterhemp, common lambsquarters and horseweed.

THE IMPACT OF NOZZLE SELECTION ON THE EFFICACY OF GLYPHOSATE AND PPO-INHIBITING HERBICIDE TANK-MIXTURES. Jesaelen G. Moraes*[1], Débora de Oliveira Latorre[2], Marcella Guerreiro de Jesus[2], Greg R. Kruger[2]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]University of Nebraska-Lincoln, North Platte, NE (120)

Herbicides have been used in agriculture by growers for several decades to control weeds. However, weeds have evolved resistances to different modes-of-action limiting the number of effective herbicides available for weed control. One of the alternatives to prevent the evolution of resistance is the use of tank-mixtures containing herbicides for post-emergence applications. In order to optimize these applications, it is essential to know the interaction between nozzle selection and herbicides. Therefore, the objective of our study was to evaluate the impact of nozzle selection on the efficacy of glyphosate and PPO-inhibiting herbicide tank-mixtures. The study was conducted as a randomized complete block factorial design in greenhouse located in UNL-WCREC in North Platte, NE using four species: kochia, *Kochia scoparia (L.) Schrad*.; horseweed, *Conyza canadensis (L.) Cronq*.; common lambsquarters, *Chenopodium album L*.; and grain sorghum, *Sorghum bicolor (L.) Moench subsp. bicolor*. Mixtures containing PPO-inhibiting herbicides (fomesafen at 0.065 kg a.i. ha^{-1} or lactofen at 0.11 kg a.i. ha^{-1}) were applied with ammonium sulfate (AMS) at 2.5% v v^{-1} and crop oil concentrate (COC) at 1% v v^{-1}. Tank-mixtures using glyphosate at 0.6 kg a.e. ha^{-1} were applied with AMS at 2.5% v v^{-1}. PPO-inhibiting herbicides and glyphosate were applied both alone and in combination. Each treatment was applied at 187 l ha^{-1}, 9.6 kph and 275 kPa. Six different nozzles with the same orifice size (04) were used: XR, AIXR, TTI, GA, TDXL, and ULD. Applications were made using a three nozzle laboratory track sprayer with nozzles spaced 50 cm apart and at 50 cm above the plants. After the plants were sprayed, visual estimations of injury were collected at 7, 14, 21 and 28 d after application (DAA). At 28 DAA, plants were clipped at the soil surface and placed in a dryer for 7 d at 48 C, and then dry weights were recorded. Furthermore, droplet size spectra were generated for these treatments using a low- speed wind tunnel at the Pesticide Application Technology Lab in North Platte, NE, with a Sympatec HELOS-VARIO/KR 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 ($p<0.0001$) for droplet size spectra, nozzle type did not affect the control of species. The main effect for the control was the interaction between solution and specie. However, its performance changed according to the specie being evaluated. Moreover, the interaction between nozzle and solution had an impact on the percent of fine droplets (<150 µm) produced. The percent of fine droplets were considerably increased when glyphosate was used alone in combination with the XR nozzle, followed by the GA, AIXR, TDXL and ULD nozzles, respectively. Whereas TTI nozzle remained stable. Since nozzle (and thereby, droplet size) was not for control of species, it is recommended to use larger droplets to minimize the drift potential of the spray application.

SPRAY DROPLET SIZE AND NOZZLE TIP PRESSURE FROM A PULSE-WIDTH MODULATION SPRAYER. Thomas R. Butts*, Liberty E. Butts, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (121)

Most equipment application technologies have struggled to provide consistent droplet sizes while owing for variable-rate applications; however pulse-width modulation (PWM) spray application systems can accommodate these requirements. PWM spray application systems control flow by pulsing an electronicy-actuated solenoid valve placed directly upstream of the nozzle. The flow is changed by controlling the relative proportion of time each solenoid valve is open (duty cycle). Although the technology appears beneficial, little research has been conducted with PWM spray application systems to investigate its influence on droplet spectrums and application parameter characteristics. The objective of this experiment was to identify the droplet size distribution and application pressure at the nozzle tip when influenced by PWM duty cycle, nozzle type, and gauge pressure. The experiment was a completely randomized factorial design conducted in the low-speed wind tunnel at the Pesticide Application Technology Laboratory in North Platte, NE using a SharpShooter® PWM system. The treatments consisted of 10 nozzle types, six PWM duty cycles, and three gauge pressures. Comparisons of droplet size data were made using the percent of fines (<150 µm) and the $D_{v0.1}$, $D_{v0.5}$, and $D_{v0.9}$ parameters which represent the droplet size such that 10, 50, and 90% of the spray volume is contained in droplets of equal or lesser values, respectively. The nozzle tip pressure was measured using a PX309, 5V, 0 – 689 kPa range pressure transducer insted inline between the PWM solenoid valve and nozzle. The analog electrical signals were sampled at a 100 Hz rate for five seconds using an Arduino Mega 2560 board. The Arduino board converted the analog signals to digital and sent them to a serial monitor on a connected computer where the signals were transformed to pressure measurements. Nozzle tip pressures at each duty cycle were standardized to the nozzle tip pressure at a 100% duty cycle. The standardized nozzle tip pressure data and the droplet distribution data were subjected to ANOVA and means were separated using Fisher's Protected LSD Test with the Tukey adjustment at $\alpha=0.05$. The analysis resulted in a nozzle*duty cycle*pressure interaction ($P < 0.0001$) for the droplet size distribution data. In general, for non-venturi nozzles, as duty cycle decreased, droplet size slightly increased. Conversely, venturi nozzles did not always follow this pattern, and larger standard errors resulted. Higher application pressures tended to minimize this droplet size change thereby stabilizing the droplet spectrums produced while pulsing. The lowest duty cycle tested (20%) negatively impacted droplet size and caused severe inconsistencies for nozzles and pressures. Nozzle tip pressures were impacted by the flow rate of a nozzle. At a 100% duty cycle, as flow rate of the nozzle increased, the nozzle tip pressure decreased, indicating a restriction is present within the solenoid valves. Moreover, duty cycle had a minimal impact on reaching the gauge pressure at each pulse for most nozzles. However, venturi nozzles were again inconsistent. In conclusion, venturi nozzles are not recommended for PWM systems as the droplet size and nozzle tip pressure patterns are lost when pulsing and therefore, applications became less consistent and more unpredictable. Furthermore, pressures ≥ 276 kPa and duty cycles > 40% are recommended to optimize applications with a PWM system.

EQUIPMENT AND CLEANING AGENTS INFLUENCE DICAMBA RINSATE DAMAGE TO SOYBEANS (*GLYCINE MAX)*. Andy J. Luke*[1], Reid Smeda[1], Jason W. Weirich[2]; [1]University of Missouri, Columbia, MO, [2]MFA Incorporated, Columbia, MO (122)

Introduction of dicamba-tolerant soybeans will result in adoption of in-season applications. However, this poses a risk for contamination of spray equipment to be used for subsequent treatment of susceptible soybeans. A field study was conducted in 2015 and 2016 in Central Missouri to assess soybean injury and yield following application with spray tank rinsates containing dicamba residues. Dicamba at 0.56 kg a.e.ha^{-1} was applied through a pulsating-pressure and constant-pressure sprayer. Spray equipment was subsequently treated with water and one of four cleaning agents (water alone, ammonia, Cleanse® or Erase®). This initial treatment was considered a first rinsate, and was followed by two rinses of water (second and third rinsate). This cycle of spraying dicamba and generating first, second and third rinsates was repeated for cleaning agents. rinsates were collected from the sprayer boom and applied on V3 or R1 soybeans. At 14 d after treatment (DAT), plant height was reduced up to 53 and 8% for first and third rinsates, respectively on V3 treated soybeans. Visible damage at 14 DAT for first rinsates ranged from 13 to 25% for V3 plants. Stunting of R1 treated soybeans ranged from 13 to 35% for first rinsates, with visible injury ranging from 13 to 31% at 14 DAT. V3 treated soybeans at 28 DAT exhibited damage ranging from 15 to 41% for first rinsate treatments and were stunted up to 48%. For R1 soybeans at 28 DAT, plants were 29 to 48% shorter and exhibited 29 to 41% injury for first rinsates. Minimal effects on plant height and injury were observed at 28 DAT for second and third rinsates on V3 soybeans. However, plant heights across third rinsate treatments ranged from 34% lower to 4% higher on R1 treated plots. Soybean yields were reduced up to 60% for R1 treated soybeans by first rinsates compared to the untreated control, while V3 treated plants exhibited yield losses up to 12% compared to the control. For third rinsates, yields ranged from 7% lower to 14% higher on R1 plants, while yields for V3 plants were increased up to 7% from third rinsates. Results were similar between each type of sprayer. Over, the type of cleaning agent appears less important than the number of rinsates. Also, the impact to soybeans was more pronounced for R1 versus V3 plants exposed to dicamba contaminated rinsate.

EVALUATION OF DRIFT FROM A FIELD APPLICATION OF ENLIST DUO™. Matthew R. Nelson*[1], W. C. Hoffmann[2], Brad K. Fritz[2], Jerome J. Schleier, III[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]USDA-ARS, College Station, TX, [3]Dow AgroSciences LLC, Indianapolis, IN (123)

Increased reliance on chemical weed control in agricultural systems has led to the evolution of herbicide resistance in various weed species, prompting the development of new weed management systems to address these concerns. These systems require careful management to ensure off-target movement is minimized, as herbicide drift from tank-mixtures such as 2,4-D and glyphosate may pose a threat to sensitive non-tolerant crops. The objective of this study was to determine the deposition and droplet size of spray particle drift resulting from an applications of Enlist Duo™ herbicide (a formulation containing 2,4-D plus glyphosate) and subsequent damage to sensitive crop species. Enlist Duo™ herbicide was applied to a fow field with a tractor mounted sprayer at a rate of 592 g a.e. ha^{-1} glyphosate and 557 g a.e. ha^{-1} and carrier volume of 140 l ha^{-1}. The AIXR11004 and TDXL11004 nozzles were tested at 276 kPa. Two lines of collectors were placed perpendicular to the center of the spray swath with potted soybean plants 60 cm in height. Collectors for airborne flux (collected 1.5 m above the ground), deposition, and droplet size placed at 1, 1.5, 2, 4, 8, 16, 32, and 64 m downwind (deposition and droplet size collected 38 cm above the ground). Mylar cards were used to collect herbicide deposition, and water sensitive cards were used to collect droplet size data. The results indicated that the amount of herbicide deposition and soybean phytotoxicity observed downwind from the site of application increased with increasing wind speed. In addition, no phytototoxicity was observed beyond 9 m downwind from the application site, which is consistent with Enlist Duo's proposed downwind buffer. Droplet size data indicated that the volume median diameter (VMD) of droplets collected downwind increased as wind speed increased.

IS EPTC A HERBICIDE OR AN ADJUVANT? Richard K. Zollinger*; North Dakota State University, Fargo, ND (124)

EPTC is a soil-applied herbicide registered for use in many major and specialty crops. It provides limited weed control applied alone. Studies were conducted in 2014, 2015, and 2016 to evaluate whether EPTC applied PRE or POST increased POST-applied herbicide efficacy. Treatments were arranged as a randomized complete block design with three replications. EPTC at 3360 or 4480 g ai ha^{-1} or ethofumesate at 280 or 560 g ha^{-1} were applied PPI in late May 2014 followed by bentazon at 70 g ha^{-1}, halosulfuron at 35 g ha^{-1}, or fomesafen at 210 g ha^{-1} applied POST to five to eight cm weeds in late June. EPTC was applied in late May 2015 at 980, 1960, 2940 g ha^{-1} followed by bentazon, halosulfuron, or fomesafen as previously described. EPTC was applied at 980, 1960, 2940 g ha^{-1} in combination with or seven days prior to bentazon, halosulfuron, or fomesafen as previously described in May 2016. Visible injury to redroot pigweed (*Amaranthus retroflexus* L.), lambsquarters (*Chenopodium album* L.), and common ragweed (Ambrosia artemisiifolia L.) was evaluated 14 and 28 DAT. EPTC applied PRE at labeled field rates increased the efficacy of all POST herbicides to greater than 90% control 14 and 28 DAT on all weeds. The benefit of EPTC was more apparent at 28 DAT when control remained higher compared to POST herbicides alone. The enhancement from EPTC was less when applied POST seven d prior or applied with POST herbicides. The rate of EPTC should be greater than 1960 g ha^{-1} in order to achieve an acceptable level of weed control. Based on the lipid synthesis inhibitor mode of action of EPTC and published research, it is thought the enhancement of EPTC on POST herbicide weed efficacy is from altering cuticle formation allowing greater spray droplet retention on leaf foliage and greater deposition of the herbicide active ingredient.

NICOSULFURON AS A SUPPRESSANT IN A LIVING MULCH OF ANNUAL RYEGRASS (*LOLIUM MULTIFLORUM* LAM.) IN CORN (*ZEA MAYS* L.). Taïga Cholette*[1], Darren E. Robinson[1], David C. Hooker[1], Peter H. Sikkema[2]; [1]University of Guelph-Ridgetown, Ridgetown, ON, [2]University of Guelph, Ridgetown, ON (125)

Living mulches are seeded at the same time, or after establishment, of a cash-generating crop to reduce nitrate leaching, sequester nutrients, reduce erosion, and improve soil health. However, a living mulch can compete with the main crop for limited resources resulting in reduced grain yield. It is hypothesized that using nicosulfuron at a fraction of its labeled rate could suppress an annual ryegrass living mulch thereby reducing competition between the living mulch and the corn crop. To investigate the hypothesis, annual ryegrass was seeded at the same time as corn at three sites in May 2016 near Ridgetown, ON. Nicosulfuron was applied at seven rates (0.8, 1.6, 3.1, 6.3, 12.5, 25 and 50 g ai ha^{-1}) at the 2-3 leaf stage or 4-5 leaf stage. Annual ryegrass control was assessed 7, 14, 28 and 56 d after application (DAA) and biomass was determined 28 DAA. Control of annual ryegrass at 28 DAA ranged from 8 to 94% as the rate of nicosulfuron increased from 0.8 to 50 g a.i. ha^{-1}, regardless of whether the herbicide was applied at either the 2-3 or 4-5 leaf stage. Nicosulfuron at 0.8, 1.6, 3.1, 6.3, 12.5, 25 and 50 g a.i. ha^{-1} applied at the 2-3 leaf stage reduced annual ryegrass biomass 30, 16, 31, 59, 79, 87 and 96%, respectively and 22, 49, 67, 76, 90, 97 and 98%, respectively when applied at the 4-5 leaf stage.

EFFECT OF COVER CROP SPECIES AND TERMINATION STRATEGIES ON WEED SUPPRESSION IN A CORN AND SOYBEAN PRODUCTION SYSTEM. Joshua J. Miller*[1], Rodrigo Werle[2]; [1]University of Nebraska - Lincoln, LINCOLN, NE, [2]University of Nebraska-Lincoln, North Platte, NE (126)

The benefits and chenges of using cover crops in agricultural production systems are often discussed anecdoty; however, research evaluating the management practices associated with cover crops is sparse. The objective of this study was to evaluate how multiple cover crop species and multiple termination strategies effect weed suppression and crop growth in a corn and soybean production system. Five winter annual cover crop treatments (cereal rye, hairy vetch, radish, three-way combination, and check) were selected to represent the most common cover crop species grown in Nebraska. Four termination strategies (early chemical termination, mechanical removal, roller/crimper, and green planting followed by chemical termination) were selected to eliminate the cover crops in the spring. Corn and soybeans were planted into each treatment. The study was conducted near Mead, NE in a RCBD with five replications. Cover crops were planted in September of 2015 and crops were planted in May of 2016. Percent ground cover was determined at two, three and four wk after planting using the Canopeo mobile application developed by Oklahoma State University. Early percent ground cover measurements indicated that there was substantial competition due to living cover crops and weed pressure. Later percent ground cover measurements were indicative of the crop stand and crop vigor in each plot. Weed biomass was evaluated later in the season to determine the abundance of two problematic weed species, common waterhemp and horseweed. In soybeans there was a interaction between cover crop species and termination strategy on over weed biomass ($p<0.0001$), number of common waterhemp ($p=0.0028$) and number of horseweed ($p<0.0001$). The results of this experiment indicate that both the cover crop species and termination strategy used can have a substantial impact on weed suppression and crop emergence and growth. The study will be conducted again in 2016/2017. Further studies are needed to refine the recommendations given to growers on how to terminate cover crops in a corn and soybean production system.

THE WISCONSIN INTEGRATED CROPPING SYSTEMS TRIAL: WEED COMMUNITIES IN CONVENTIONAL CORN AND SOYBEAN PRODUCTION SYSTEMS AFTER 27 YEARS. Nathan M. Drewitz*, David E. Stoltenberg; University of Wisconsin-Madison, Madison, WI (127)

Long-term experiments aid in our understanding of how cropping systems affect weed community dynamics over time. The Wisconsin Integrated Cropping Systems Trial

(WICST) was established in 1989 to compare the productivity, profitability, and environmental impact of a wide range of cropping systems, including two conventional grain cropping systems: chisel-plow (CP) continuous corn and strip-tillage (ST) corn/no-tillage (NT) soybean rotation. Previous research has shown that ST conserves soil, reduces production costs, and saves time compared to conventional tillage such as CP, but we have little information on weed management risks in ST systems in the northern Corn Belt. To address this information gap, research was conducted in 2015 and 2016 to characterize the weed seedbank and plant community composition, emergence patterns, productivity, and suppression in the ST corn/NT soybean rotation and CP continuous corn systems in WICST. The WICST is located at the University of Wisconsin-Madison Arlington Agricultural Research Station near Arlington, WI on a Plano silt loam soil. The experimental design was a randomized complete block with four replications. Plot area was 0.3 ha. Each cropping system phase was replicated in time as well as in space, such that both phases of the ST corn/NT soybean rotation occur in each year. Glyphosate, *s*-metolachlor, and 2, 4-D were applied PRE in ST corn and NT soybean followed by glyphosate and tembotrione POST in ST corn and glyphosate and bentazon POST in NT soybean. Glyphosate and tembotrione were applied POST in CP corn. Across years, common lambsquarters, eastern black nightshade, and yellow foxtail were the most abundant species in CP corn based on plant density at canopy closure in non-treated quadrats. In both ST corn and NT soybean, common lambsquarters, redroot pigweed, and eastern black nightshade were the most abundant species across years. Total weed density in non-treated quadrats in CP corn was similar to or greater than in ST corn across years. Total weed density was lowest in NT soybean among phases in each year. Time to 50% maximum weed emergence did not differ between CP corn and ST corn in either year. Common lambsquarters accounted for most of the late-season weed shoot biomass in non-treated quadrats in each cropping phase across years and did not differ between ST corn and CP corn in either year. In treated quadrats biomass was very low and did not differ among systems in either year. The total germinable weed seedbank in the upper 15 cm of the soil profile did not differ between the ST corn and CP corn. These results indicate that weed seedbank and plant community composition did not differ greatly among the three cropping phases. Weed emergence patterns, maximum densities, and shoot biomass did not differ between ST corn and CP corn. These results suggest that adoption of conservation-tillage ST corn/NT soybean systems is not expected to be associated with increased weed management risks compared to conventional-tillage production systems in the northern Corn Belt.

EFFICACY OF PRE AND POST APPLIED DICAMBA ON DICAMBA-RESISTANT KOCHIA. Junjun Ou*[1], Curtis R. Thompson[1], Phillip W. Stahlman[2], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Research and Extension, Hays, KS (128)

Kochia (*Kochia scoparia*) is one of the most troublesome weeds throughout the North American Great Plains. Post-emergence (POST) application of dicamba to control kochia is not a viable option as a result of evolution and spread of dicamba resistance across the Great Plains. To test if preemergence (PRE) applied dicamba could be an alternative to managing dicamba-resistant (DR) kochia, 210, 280, 350, and 420 g a.e.ha^{-1} of dicamba (Clarity®) was applied as PRE and compared with POST application at 560 g a.e.ha^{-1} on both DR and dicamba-susceptible (DS) kochia. These treatments were also tested in soils with low and high organic matter (OM) content. Furthermore, efficacies of PRE applied dicamba were also compared at DR and DS kochia densities of 300, 600, 900 and 1200 seed m^{-2}. Analysis of plant survival and dry biomass data at eight wk after PRE and four wk after POST treatment suggest better control of both DR and DS kochia with PRE applied dicamba at 350, 420 g ae·ha^{-1} than POST at 560 g a.e.ha^{-1}. The organic matter content in soil did not affect the results. Additiony, the efficacy of PRE applied dicamba was negatively correlated with seed density. In conclusion, PRE applied dicamba (full recommended dose) can be a viable tool to manage DR kochia, regardless of soil organic matter content.

TRANSCRIPTOME EXPRESSION ANALYSIS OF 4-HYDROXYPHENYLPYRUVATE DIOXYGENASE INHIBITOR HERBICIDE RESISTANCE IN *AMARANTHUS TUBERCULATUS* USING RNA-SEQUENCING. Daniel R. Kohlhase*[1], Mike D. Owen[1], Michelle A. Graham[2]; [1]Iowa State University, Ames, IA, [2]USDA-ARS, Ames, IA (129)

Amaranthus tuberculatus (Moq.) J.D. Sauer is a problem weed in the midwestern U.S. and has the potential to cause yield losses up to 74% in maize (*Zea mays* L.) and 56% and soybean [*Glycine max* (L.) Merr.]. *A. tuberculatus* has been documented to evolve resistance to six herbicide sites of action and thus an important species for herbicide resistance research. p-hydroxyphenylpyruvate-dioxygenase (HPPD, EC 1.13.11.27) inhibitor herbicide resistance was first reported for *A. tuberculatus* in 2011. After the initial reports of HPPD-herbicide resistance, studies have identified one mechanism of resistance and described the inheritance of the herbicide resistance trait. Initial attempts to use genomic resources to identify important herbicide target site sequences within in the *A. tuberculatus* genome were initiated. To date, no studies have examined the transcriptomic expression response of HPPD-herbicide resistance in *A. tuberculatus*. Even with preliminary attempts to sequence the *A. tuberculatus* genome, the genomic resources of *A. tuberculatus* remains limited; therefore, we conducted an RNA-sequencing (RNA-seq) *de novo* transcriptome assembly of *A. tuberculatus*. We treated and mock-treated two (*A. tuberculatus)* populations (HPPD-herbicide resistant and susceptible) with mesotrione and collected leaf samples at 3, 6, 12, and 24 hr after treatment (HAT). This *de novo* assembly was then used to measure transcript expression differences between genotypes, treatments and time points. Our results indicate that the response of HPPD-herbicide resistant and susceptible (*A. tuberculatus)* genotypes to mesotrione is very rapid and measureable as soon as three HAT. Furthermore, little overlap was found among the differentiy expressed transcripts expressed by each genotype. We also identified the possibility of overlapping gene networks in response to other herbicides. The raw sequences, and assembled sequences with complete annotations will be made available for continued use by the weed science community.

BIOLOGICAL RESPONSE OF PALMER AMARANTH (*AMARANTHUS PALMERI*) AND COMMON WATERHEMP (*AMARANTHUS RUDIS*) TO HERBICIDE DRIFT. Bruno Canella Vieira*, Matthew R. Nelson, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (130)

The effects of herbicide-drift on sensitive crops have been extensively investigated and reported in the literature. However, little or no information regarding the effects of herbicide-drift on weeds have been reported. Herbicide-drift can represent a sub-lethal rate of exposure to weeds, especiy for those located on the edges of the fields. Sub-lethal rates of herbicides have been reported to influence the herbicide resistance evolution in some weed species. Therefore, the objective of this study was to investigate the application droplet size, deposition pattern, and biological effect of herbicide-drift on Palmer amaranth and common waterhemp plants at different downwind distances from the nozzle. This study was conducted in a wind tunnel at the Pesticide Application Technology Lab (University of Nebraska – Lincoln, West Central Research and Extension Center, North Platte, NE). Glyphosate, dicamba, and 2,4-D applications (140 l h^{-1}) were simulated using two different nozzles (AI95015EVS and TP95015EVS) at 140 kPa under a 16 kmh airstream. Palmer amaranth and common waterhemp plants were positioned at different downwind distances in the wind tunnel (0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 7, and 12 m from the nozzle). Mylar and water sensitive cards were used at each downwind distance as drift collectors. The percentage of drift was estimated by fluorimetry as a fluorescent tracer was added to the herbicide solution. Visual estimations of injury and percentage of biomass reduction were recorded at 21 DAT for Palmer amaranth and common waterhemp plants. Droplet size spectra were evaluated using a Sympatec Helos laser diffraction instrument. The air induction nozzle reduced the percentage of drift for herbicide applications. Observed herbicide injury decreased as the downwind distance increased, especiy when applications were made with the air induction nozzle. The study results indicate that herbicide–drift can be considered a sub-lethal rate of exposure to weeds surrounding fields in an herbicide application. Understanding and mitigating herbicide-drift exposure may represent an important strategy to delay herbicide-resistance evolution in weeds.

TEMPERATURE EFFECT ON EFFICACY OF POST-HERBICIDES TO CONTROL PALMER AMARANTH (*AMARANTHUS PALMERI*) IN GRAIN SORGHUM. Seth Menzer*, Mithila Jugulam, Curtis R. Thompson; Kansas State University, Manhattan, KS (131)

Grain sorghum yields are influenced by weeds, especiy Palmer amaranth infestations. POST herbicide application is a major method for Palmer amaranth control in sorghum. POST herbicide efficacy may be influenced by environmental factors, including temperature. Short episodes of high daily temperature during sorghum production are common across the central Great Plains. The objective of this study was to evaluate the efficacy of POST applied herbicides on Palmer amaranth when exposed to different temperatures under controlled growth chamber and field conditions. In growth chambers, Palmer amaranth plants were grown under two different temperature regimes, the first modeling long-term average Kansas temperatures in late June (AT), and the second modeling the extreme temperatures observed in western Kansas throughout June and July of 2012 (ET). Ten to twelve cm t plants were treated with dicamba (1X=560 g a.e. ha^{-1}), atrazine (1X=2240 g a.i. ha^{-1}) or Huskie™ (pyrasulfotole&bromoxynil 1:5.65 ratio, 1X=288 g a.i. ha^{-1}) at a wide range of doses at either 8:00 am (22 C AT, 25 C ET) or 4:00 pm (30 C AT, 35 C ET). Visual control of weeds relative to untreated plants was recorded at one, two and three wk after treatment (WAT), and final biomass was determined three WAT. Field experiments were also conducted in 2015 and 2016. Huskie (235 or 288 g a.i. ha^{-1}) + atrazine (560 g a.i. ha^{-1}) or bromoxynil (420 g a.i. ha^{-1}) + atrazine (560 g a.i. ha^{-1}) were applied at 8:00 am (cooler) or 4:00 pm (hotter) on V3 and V8 stage sorghum. Visual weed control was evaluated one, two and four WAT. Preliminary results from growth chamber experiments indicate no difference in Palmer amaranth control at temperatures regimes between the 8:00 AM and 4:00 PM applications, while at the extreme temperature regime, data is still forthcoming. Field data from 2015 indicated a difference in control between 8 AM and 4 PM only for bromoxynil applied at the V8 stage. Understanding temperature effects on herbicide efficacy is important for recommending application times for POST herbicides that improve weed control in grain sorghum.

HOW ATTITUDES ABOUT COMMUNITY CAN CONTRIBUTE TO HERBICIDE RESISTANT PALMER AMARANTH. John A. Pauley*, Maggie E. Long, Zoe G. Muehleip; Simpson College, Indianola, IA (132)

During research on the spread of Palmer amaranth, we interviewed a wide range of agricultural stakeholders, including farmers and crop advisors. We found consistent evidence that the farming community is not disposed to collaboration due to the competitive nature of the market. This competition is relatively new in the culture of farming, brought about by pressures for producers to increase personal yields. However, the absence of collaboration could be detrimental when dealing with herbicide-resistant weeds, specificy Palmer amaranth. Due to the Palmer amaranth's propensity to develop herbicide resistance and establish seed banks, it has potential to devastate Iowa's agriculture. Increased communication between farmers about Palmer appearances and resistances observed is essential. This collaboration could further prevent misidentifying Palmer amaranth as waterhemp. Collaboration between counties and farmers is also necessary because seed banks are often left unmanaged on public lands such as ditches. Before effective collaboration is possible, attitudes about community must change.

RESPONSE OF THREE ALTERNATIVE WEED HOSTS AND TWO CORN HYBRIDS TO DIFFERENT INOCULUM LEVELS OF *CLAVIBACTER MICHIGANENSIS* SUBSP. *NEBRASKENSIS*, CAUSAL AGENT OF GOSS'S WILT. Taylor M. Campbell*[1], Joseph T. Ikley[2], Kiersten A. Wise[2], William G. Johnson[3]; [1]Purdue University, Lafayette, IN, [2]Purdue University, LAFAYETTE, IN, [3]Purdue University, West Lafayette, IN (133)

Goss's wilt is a bacterial disease in corn (*Zea mays*) caused by *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). In recent years this disease has reemerged and been found in new states located throughout the Midwest. Research on Cmn has confirmed alternative hosts for the disease and limited research has been conducted to determine the influence they have on the bacteria. A greenhouse study was conducted in 2014 and 2015 to determine the susceptibility of annual ryegrass (*Lolium multiflorum*), giant foxtail (*Setaria faberi*), and johnsongrass (*Sorghum halepense*) compared to a susceptible and moderately resistant corn hybrid. Plants were inoculated with inoculum concentrations of 1×10^0 to 1×10^7 colony forming units (CFU) ml^{-1}. Plants were inoculated with both the cut and dip method and the pricked and sponged method on separate leaves. The two corn hybrids had greater amounts of lesion development for the two inoculation techniques compared to the alternative hosts. The two corn hybrids had an increase in disease severity as inoculum levels increased while alternative hosts showed slight increases in disease severity as inoculum levels increased. Time for initial lesion development to occur was also measured and compared amongst the different hosts and inoculum levels. Hosts responded similar for initial lesion development except annual ryegrass which was slower for initial symptoms to develop. When compared in a single species, the inoculum levels were observed with a decrease in the amount of d required for initial lesion development to occur as inoculum levels increased. Hosts consistently developed lesions at the 1×10^4 CFU ml^{-1} inoculum level, this implies that low inoculum levels that may be more common in a producer's field are enough to cause infection on both corn and alterative hosts. Therefore, producers need to use multiple cultural practices to reduce field inoculum levels while also using crop rotation, hybrid selection, and controlling alternative hosts to reduce disease severity in the field.

HERBICIDE TIMING FOR EFFECTIVE CONTROL ON RAILROADS IN THE MID-WEST. Matthew R. Terry*, Reid Smeda; University of Missouri, Columbia, MO (134)

Vegetation at road crossings for railroad right-of-ways is highly controlled to ensure motorist safety and minimize fire hazards. For season-long control, a residual herbicide is traditiony applied early in the growing season; multiple post-emergence applications are made to weeds that subsequently emerge. A field study in central Illionois (Villa Grove) and Missouri (Columbia) was established in 2015 to compare f versus spring as well as overlapping residual programs. The objective of this research was to identify the optimum timing of residual herbicides to minimize late season weed populations. Eight treatments were applied in a randomized complete block design with four replications. Two prominent residual programs were compared: flumioxazin + pyroxasulfone + aminocyclopyrachlor + chlorsulfuron (program 1); and indaziflam + aminocyclopyrachlor + chlorsulfuron (program 2). Each chemical program was applied as follows: f, full rate; f followed by spring, half-rates; spring, full rate; spring followed by summer, half-rates. Glyphosate + triclopyr was applied with residual programs or alone as needed when weed growth reached 10 to 15 cm. Data collection included vegetative cover as percent bareground and visual control of each species (0-100%) at 20, 50 and 90 d after treatment (DAT) from the spring residual timing. At 20 DAT, percent bareground for treatments ranged from 87 to 99%. At 50 DAT, treatments with a spring applied residual ranged between 80 to 98%, while full rate f residual applications ranged between 79 and 87% bareground. At 90 DAT, percent bareground for program 1 timings ranged from 82 to 96%. Percent bareground for program 2 timings ranged from 64 to 79% bareground; however, the full rate applied in f was 99% bareground. For both programs, split applications of two half-rates resulted in higher weed control compared to single timings using full rates. There were no differences between f full rate and spring full rates as well as no differences between f + spring and spring + summer half-rate timings. F application of half-rates of an effective residual program delays the necessary timing of spring half-rates up to 22 d compared to no f application. This delay resulted in eliminating the need for a mid-summer post-emergence application.

RELATIONSHIPS BETWEEN WEED INCIDENCE, SOIL FERTILITY, AND SOIL PH IN MISSOURI PASTURES. Zach L. Trower*[1], Mandy D. Bish[2], Meghan Biggs[1], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (135)

In Missouri, pastures account for 526,000 hectares of land, and grazing land also occupies about 33% of the total land use in the U.S. Weeds are the predominate pest in pastures, costing producers approximately two billion dollars annuy. The purpose of this research was to determine if correlations could be found between weed incidence, forage density and soil pH and nutrient levels in pasture environments. A total of 26 Missouri pastures were survey during the 2015 growing season and 20 were surveyed in 2016. At each pasture site, one 20-m^2 area was surveyed for every four ha within a given pasture. The GPS coordinates of each survey area were recorded, and these areas were re-visited every 14 d between April and October. Weed density, height, and stage, as well as grass and legume forage heights and ground cover were recorded for every site at each two-wk interval. Soil samples were collected from each survey area to determine soil pH as well as soil phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sulfur (S), zinc (Zn), manganese (Mn), and copper (Cu) levels. Linear regression analyses were conducted in SAS to determine the relationships between weed density and soil pH and nutrient levels. The ten most common weeds found across 46 pastures surveyed included horsenettle (*Solanum carolinense* L.), common ragweed (*Ambrosia artemisiifolia* L), nutsedge species (*Cyperus* spp. L.), annual fleabane (*Erigeron annuus* L.), vervain species (*Vervain* spp.*)*, yellow foxtail (*Setaria pumila* P.), broadleaf plantain (*Plantago major*), Virginia copperleaf (*Acalypha virginica* L.), dandelion (*Taraxacum officinale* F.H.), and t ironweed [*Vernonia gigantea* (Walt. Trel.)]. Annual weeds genery increased throughout the spring and reached their peak density in mid-July. Perennial weeds genery increased throughout the spring and early summer and reached their peak density in August. Preliminary soil analysis results for the 2015 and 2016 pastures show that for every part per million (ppm) increase of P, K, and Ca, weed density decreased by 0.9, 0.07, and 0.02 plants per 20-m^2 area, respectively. Similarly, for every one-unit increase in soil pH, weed density decreased by 20.6 plants per 20-m^2 area. The preliminary indicate that soil pH and nutrient levels have an effect on weed density in pastures. This research will be useful to help producers plan comprehensive weed management programs that includes proper maintenance of soil fertility and pH.

SOYBEAN (*GLYCINE MAX* L.) YIELD LOSS AS AFFECTED BY COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA* L.) AND COMMON WATERHEMP (*AMARANTHUS RUDIS* SAUER) IN NEBRASKA. Koffi Badou Jeremie Kouame*; University of Nebraska-Lincoln, Lincoln, NE (136)

Understanding the combined effect of common waterhemp and common ragweed on soybean will be helpful for the development of accurate and predictive crop yield loss models as both species are genery present in fields and compete with the crop. Field experiments were conducted in 2016 in Nebraska to determine the influence of variable water supply on the multispecies interference of commin ragweed (*Ambrosia artemisiifolia L*.) and common waterhemp (*Amaranthus rudis Sauer*) on soybean (*Glycine max L*.) yield. The experiment was a split-plot design with four replicates, three irrigation levels (full irrigation, half irrigation, and no irrigation) as the main plot and four weed densities as the subplot. The experiment was set up as an additive design where common ragweed and common waterhemp were seeded at a high rate and thinned to an appropriate ratio of 50:50 (0, 1, 3, 6) giving total weed densities of 0, 2, 6, and 12 plants m^{-1} of row. Common waterhemp emerged 12 d after soybean while common ragweed emerged four d after soybean. The multispecies rectangular hyperbola model coefficients, mean weed-free yield, percent yield loss as density approaches zero, and maximum yield loss as weed density approaches infinity were not different between water levels. As there was no water effect on competition, the data were pooled. Results reveal that common ragweed was more competitive than common waterhemp. Yield loss associated with the first equivalent common ragweed plant was 85%. In this multispecies competitive environment, the maximum yield loss was 69% while the maximum weed free yield was 4,939 kg ha-1.

OVEREXPRESSION OF A NATIVE GENE ENCODING 5-ENOLPYRUVYLSHIKIMATE-3-PHOSPHATE SYNTHASE CAN ENHANCE FECUNDITY IN *ARABIDOPSIS THALIANA*. Zachery T. Beres*, Xiao Yang, Lin Jin, David M. Mackey, Jason T. Parrish, Wanying Zhao, ison A. Snow; Ohio State University, Columbus, OH (137)

Testing for underlying fitness effects related to glyphosate resistance can be confounded by variable genetic backgrounds in weed populations. To avoid this problem, we used transgenic *Arabidopsis thaliana* to study phenotypic effects of over-producing EPSPS, a resistance mechanism found in at least seven weed species. We engineered a binary vector expressing a native *EPSPS* gene from *Arabidopsis* under control of the CaMV35S promoter (denoted as OX, for overexpression) and an empty vector (denoted EV). We produced six OX and seven EV independent, homozygous T3 lines for each construct. Here, we report results from a glyphosate dose-response experiment, a gene expression experiment, and two greenhouse fitness experiments. OX lines were more resistant to glyphosate and had ED_{50} values that were ~7- to 23-times greater than those for EV lines (dose-response models from the *drc* package in R). Quantitative real-time PCR was used to estimate gene expression of *EPSPS* relative to the native *Actin7* gene. OX lines with enhanced glyphosate resistance had ~24- to 66-fold greater *EPSPS* expression than EV or wild-type controls, which were similar to each other. Results from these experiments showed consistent patterns in levels of glyphosate resistance among the OX, EV, and wild-type lines, and enhanced resistance was positively correlated with levels of *EPSPS* gene expression across vegetative and flowering stages of development. In the absence of glyphosate, fitness experiments showed that two of the OX lines produced more seeds plant^{-1} than wild-type or EV lines, while the other OX lines were not different from the wild-type. Fecundity of the EV lines was similar to or less than that of wild-type lines. Other traits measured included: longest leaf length of rosettes, number of fruits plant^{-1} and seeds per fruit, and flowering time. Based on results from the EV lines, there appeared to be a fitness cost related to the insertion of the binary vector in some cases. However, we suggest that over-production of EPSPS compensated for this cost. Our results are consistent with the hypothesis that over-production of EPSPS in *Arabidopsis* does not have a fitness cost and may have a fitness benefit.

PHYSICAL MAPPING OF *EPSPS* GENE COPIES IN GLYPHOSATE-RESISTANT ITALIAN RYEGRASS (*LOLIUM PERENNE SSP. MULTIFLORUM)*. Karthik Putta*[1], Dal-Hoe Koo[1], Vijaya k. Varanasi[1], Rand S. Currie[2], Nilda R. Burgos[3], Mithila Jugulam[1]; [1]Kansas State University, Manhattan, KS, [2]Kansas State Univ., Garden City, KS, [3]University of Arkansas, Fayetteville, AR (138)

Italian ryegrass, one of the problem weeds of the U.S., evolved resistance to multiple herbicides including glyphosate due to selection in Arkansas. Glyphosate is a 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) inhibitor and amplification of *EPSPS* gene, the molecular target of this herbicide contributes to resistance in several weed species, including an Italian ryegrass population from AR. The objective of this study was to determine the expression of *EPSPS* gene and protein as well as distribution of *EPSPS* copies on the genome of glyphosate-resistant Italian ryegrass (ARR) using a known susceptible Italian ryegrass (ARS) from AR. *EPSPS* gene copies and expression of ARR and ARS were determined using quantitative PCR with appropriate endogenous control. EPSPS protein expression was determined using Western blot analysis. Fluorescence in situ hybridization (FISH) was done on somatic metaphase chromosomes to determine the location of *EPSPS* copies. Based on qPCR analysis, ARR plants showed 12 to 118 *EPSPS* copies compared to ARS. *EPSPS* gene expression correlated with the gene copy number in both ARR and ARS. Individuals with high *EPSPS* copies showed high protein expression in Western blot analysis. Preliminary FISH analysis showed presence of a brighter *EPSPS* signal, distributed randomly throughout the genome of ARR individuals compared to a faint signal in ARS plants. Random distribution of *EPSPS* copies was previously reported in glyphosate-resistant Palmer amaranth. Over, the results of this study will help understand the origin and mechanism of *EPSPS* gene amplification in Italian ryegrass.

INVESTIGATIONS INTO TARGET-SITE AND NON-TARGET-SITE RESISTANCE MECHANISMS IN HPPD RESISTANT WATERHEMP FROM NEBRASKA. Maxwel C. Oliveira*[1], Franck Dayan[2], Todd Gaines[2], Jon E. Scott[1], Stevan Knezevic[1]; [1]University of Nebraska-Lincoln, Concord, NE, [2]Colorado State University, Fort Collins, CO (139)

In 2012, a Nebraska waterhemp biotype was confirmed resistant to POST-applied 4-hydroxyphenylpiruvate-dioxygenase (HPPD)-inhibiting herbicides (mesotrione, tembotrione, and topramezone). Therefore, a total of 3 sets of studies (laboratory, greenhouse, and field) were conducted to assess whether target-site resistance or metabolism-based resistance might be the mechanism of resistance in the HPPD-resistant waterhemp biotype (HPPD-R). In the first set, a laboratory study evaluated target-site resistance mechanisms, including HPPD relative gene amplification and HPPD gene sequencing of both HPPD-R and HPPD-S (waterhemp susceptible biotype). Results demonstrated that there is no HPPD-R gene amplification and no mutation in the HPPD-R gene; therefore there is no evidence that the mechanism is target-site resistance for this HPPD-R. In the second set, field and greenhouse studies evaluated the metabolism-based resistance in the HPPD-R. Three cytochrome P450 inhibitors (malathion, amitrole, and PBO) followed by (fb) mesotrione or tembotrione were applied to evaluate the level of HPPD-R control and biomass production. Results revealed that amitrole synergized with mesotrione, improving HPPD-R control and reduction of biomass; but PBO and malathion did not synergize mesotrione. In contrary, malathion, amitrole, and PBO synergize tembotrione, provided > 90% HPPD-R control. In the third set, mass chromatography was utilized to further check the outcome from the second set. The results from the third set of studies provided some evidence that the mechanism of HPPD-R is metabolism-based resistance. For example, when either PBO or malathion fb mesotrione and mesotrione alone was sprayed in the HPPD-R, less than 19.5 hr was necessary to reduce 50% of mesotrione in the HPPD-R. In contrary, when amitrole fb mesotrione was sprayed, 50% of mesotrione remain in the leaves up to 28.3 hr in the HPPD-R. Furthermore, after application of mesotrione alone, a 36.4 hr was needed to reach 50% mesotrione metabolism in HPPD-S. These results provided some evidence that the mechanism of HPPD-R from Nebraska is metabolism-based resistance. However, an alternative hypothesis might be that multiple genes conferring enhanced metabolism do exist in the HPPD-R from Nebraska. Further studies are needed to test such hypothesis.

SAFENER INDUCED EXPRESSION OF TANDEMLY DUPLICATED GSTS USING VALIDATED REFERENCE GENES IN SORGHUM SHOOTS. Loren V. Goodrich*; University of Illinois Urbana-Champaign, Savoy, IL (140)

Safeners are frequently used with herbicides that normy cause injury in unsafened grain sorghum (*Sorghum bicolor*), and are typicy applied as seed treatments to avoid safening weedy sorghum relatives. Safeners confer protection to cereal crops by inducing herbicide detoxification and defense systems, including massive increases in the expression and activity of glutathione *S*-transferases (GSTs) and P450s, although their precise mechanisms-of-action remain unknown. Therefore, our objectives were to identify key genetic factors in the safener-induced detoxification pathway using a genome-wide association study to evaluate 800 diverse sorghum lines and quantify the expression of important genes identified. Greenhouse studies were conducted with preemergence *s*-metolachlor, plus or minus the safener fluxofenim as a seed treatment, to determine phenotypes for natural herbicide tolerance and safener-induced responses. Data analysis revealed that the molecular marker most associated with safener-induced response was located on chromosome 9, a SNP located within a phi-class *SbGST* gene and about 15 kb from a different phi-class *SbGST*. Transcript levels of these two candidate *SbGSTs* were quantified in etiolated shoot tissues by utilizing quantitative reverse-transcriptase (qRT)-PCR and gene-specific primers designed from each *SbGST* coding region. Basal and safener-induced expression of the *SbGSTs* was examined in three sorghum genotypes from 4 to 12 HAT to quantify safener induction of these genes relative to three stably expressed reference genes. Results indicated that expression of each *SbGST* gene increased within 12 hr following safener treatment but differed by specific gene and genotype, suggesting that these *SbGSTs* play a functional role in the safening response from herbicides. Future experiments aim to identify signaling and/or metabolic genes that play a role in safener induction of herbicide detoxification pathways. This information will facilitate the discovery of new chemicals to enhance crop tolerance to herbicides, as well as assist in developing marker-based assays to screen and identify sorghum lines with an increased safener response.

HOW MUCH DOES HORSEWEED (*CONYZA CANADENSIS*) HEIGHT OR DEVELOPMENTAL STAGE INFLUENCE THE EFFICACY OF HALAUXIFEN-

METHYL, DICAMBA, AND 2,4-D? Cara L. McCauley*, Bryan Young; Purdue University, West Lafayette, IN (141)

Horseweed (*Conyza canadensis*) is a problematic broadleaf weed species in many cropping systems. Since the discovery of glyphosate-resistant (GR) horseweed in 2001, the auxin herbicides 2,4-D and dicamba have been commonly used to control horseweed prior to planting corn or soybean. Halauxifen-methyl is a new auxin herbicide and is currently under development with the potential to provide GR horseweed control under a range of varying environmental conditions. In 2015 and 2016, a field experiment was conducted at two field sites to investigate the influence of horseweed height on the efficacy of 2,4-D, dicamba, and halauxifen-methyl. Twelve horseweed plants ranging from 5 to 30 cm t were marked in each plot and heights were recorded at the time of herbicide application. Herbicide applications included halauxifen-methyl (2.5, 5, 10 g ae ha^{-1}), dicamba (140, 280, and 560 g a.e. ha^{-1}), and 2,4-D (280, 560, and 1120 g a.e. ha^{-1}) which represents an approximate 1/2X, 1X, and 2X of the typical field use rate for each of the herbicides. In addition, glyphosate was combined with each of the auxin herbicides at the 1X rate. Across years and locations, the 1X rates of halauxifen-methyl and dicamba controlled horseweed up to 19 and 24 cm in height, respectively, while the 1X rate of 2,4-D was only efficacious on horseweed up to three cm in height. The addition of glyphosate was beneficial for control of horseweed only when applied with 2,4-D since the efficacy of both dicamba and halauxifen-methyl was relatively high when applied alone. A greenhouse dose response experiment was designed to supplement the field research and evaluate differences in herbicide efficacy when applied to rosette-sized plants compared to 10- and 20-cm bolted horseweed plants under controlled environmental conditions. The efficacy of halauxifen-methyl on horseweed in the greenhouse was similar to dicamba in terms of weed size in the field. These results indicate that halauxifen-methyl has the potential to be utilized to control GR horseweed with equivalent or greater control than other current auxin herbicide standards.

OCCURENCE OF GLYPHOSATE-RESISTANT HORSEWEED (*CONYZA CANADENSIS*) IN RANGELAND AREAS OF WEST CENTRAL NEBRASKA. Débora de Oliveira Latorre*[1], Spencer L. Samuelson[1], Jesaelen G. Moraes[2], Rodrigo Werle[1], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]University of Nebraska-Lincoln, Lincoln, NE (142)

Horseweed (*Conyza canadensis*) is widely distributed in the U.S. in crop and rangeland. Areas it has become very problematic in agriculture because of its evolved resistance to glyphosate and other herbicides. Understanding the dispersal of horseweed seeds is important to estimate the possible areas that could be impacted when a resistant population is established. The objective of this study was to evaluate the status of herbicide-resistance in horseweed populations in non-crop areas of Nebraska and explain how weed management may influence herbicide resistance. Thirty horseweed populations were collected from rangeland areas in 17 counties across Nebraska, including as control a known susceptible population. Dose-response studies were conducted in greenhouse located at the West Central Research and Extension Center in North Platte, Nebraska. The experiment measured the response of the populations to nine glyphosate doses: 0, 0.22, 0.43, 0.87, 1.74, 3.47, 6.94, 13.89 and 27.78 kg a.e. ha^{-1}. Visual estimations of injury were collected for individual plants at 3, 7, 14 and 21 d after treatment (DAT). At 21 DAT, plants were severed at the base and dried to constant weight. Growth reduction (GR) was calculated at 21 DAT. The study was arranged as factorial arrangement of treatments (nine herbicide rates x 30 populations) in randomized complete design (RCD) with five replications. The dry weight data and visual estimations of injury were analyzed using a nonlinear regression model with the *drc* package in R 3.1.1. Glyphosate dose necessary to achieve a 50% of GR were estimated for each population using a four parameter log logistic equation: y=c+(d-c/1+exp(b(log x-log e))). The R:S ratios were calculated by dividing the GR_{50} or GR_{90} of the resistant population by their relative GR_{50} or GR_{90} value of the known susceptible population. Horseweed populations showed different susceptibility to glyphosate. The major GR_{50} value was 0.16 kg ha^{-1}, while GR_{90} was 1.8 kg ha^{-1}.Potentiy resistant horseweed pollen and seeds can be easily dispersed over long distances by the wind and plants quickly become established in different crop and non-crop areas. Mitigating herbicide selection pressure plays an important role in reducing the herbicide-resistant frequency. Researchers have hypothesized that glyphosate-resistant can be expected with some fitness cost, therefore resistant biotypes can have some disadvantage in the absence of the selective agent relative to susceptible biotypes.

ATOMIZATION OF POLYMER TANK-MIXTURES WITH PICLORAM AND 2,4-D. Henrique Campos*, Bruno Canella Vieira, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (143)

Aerial applications of picloram and 2,4-D on pasture can be an issue due to the negative effects of the spray drift on the nearby vegetation and sensitive crops. Polymers are other adjuvants that can reduce drift, can influence the droplet size spectra of these herbicides. The objective of this study was to evaluate the impact of different polymers on the droplet size spectra of picloram and 2,4-D. The study was conducted in a high speed tunnel at a wind speed of 250 kmh^{-1}. The herbicide picloram and 2,4-D (Grazon P+D™) was used at a rate of 4.68 l ha^{-1}. The polymers Array™ (10.8 g l^{-1}), Border Xtra 8L™ (2.5% v v^{-1}), Strike Zone DF™ (7.9 g l^{-1}), Reign LC™ (0.3 ml l^{-1}) and Pro-Mate Accuracy™ (0.3 ml l^{-1}) were also used. The experiment was ran with a spray volume of 50 l ha^{-1} using CP11 – 8008 nozzles at 276 kPa. Droplet size spectrum data were analyzed in SAS (PROC GLIMMIX) and means were log transformed. The droplet size based on polymers was ranked from smest to largest according to the $Dv_{0.5}$ values: Pro-Mate Accuracy™, Strike Zone DF™, Border Xtra 8L™, Array™ and Reign LC™. Furthermore, the use of polymers increased the number of droplets <100 µm and the relative span values. Use of polymer based adjuvants for aeial applications can increase the risk of drift and should be used cautiously.

ATUGSTF2 EXPRESSION STRONGLY CORRELATES WITH ATRAZINE RESISTANCE IN A SEGREGATING *AMARANTHUS TUBERCULATUS* F2 POPULATION. Sarah O'Brien*; University of Illinois Weed Science Department, Urbana, IL (144)

Maize (*Zea mays*) and grain sorghum (*Sorghum bicolor*), as well as some grass weeds such as f panicum (*Panicum dichotomiflorum*) and wild-proso millet (*Panicum miliaceum*), are natury tolerant to atrazine due to high levels of glutathione *S*-transferase (GST) activity. However, due to the widespread use of atrazine, numerous dicot weed species have become resistant to *s*-triazine herbicides through target site and non-target site mechanisms. Previous research indicated that two atrazine-resistant populations of waterhemp (*Amaranthus tuberculatus*) from Illinois (designated ACR and MCR) display enhanced rates of atrazine metabolism via glutathione conjugation. Several unique waterhemp peptides revealed by LC-MS/MS from glutathione affinity-purified protein fractions led to the identification of several waterhemp *GST* cDNAs. Elevated constitutive expression levels of a single phi-class *GST*, named *AtuGSTF2,* correlated with atrazine resistance in the ACR and MCR populations. Using this information, our objective was to evaluate whole-plant responses to post-emergence (POST) atrazine applications combined with *AtuGSTF2* expression analyses to test the hypothesis that phenotypes of segregating F_2 lines derived from an MCR x WCS (atrazine-sensitive) cross will correlate with constitutive *AtuGSTF2* expression. Genotypes fing into three distinct categories (RR, Rr, or rr) were tentatively assigned based on their varying phenotypic responses to a discriminating rate of atrazine (14.4 kg ha^{-1}) applied POST in the greenhouse to 10- to 12-cm tall plants. Total RNA was extracted from several F_2 lines representing each genotypic class (based on whole-plant responses) and basal *AtuGSTF2* expression levels were quantified and compared via qRT-PCR. Results showed that each atrazine-resistant line (RR and Rr) tested displayed high *AtuGSTF2* expression levels, ranging from 200- to 1140-fold greater than the low baseline levels detected in atrazine-sensitive lines (rr). Sequence analysis of RT-PCR products revealed several elic variants of the *AtuGSTF2* gene among F_2 lines and their parent populations. These results demonstrate that constitutive *AtuGSTF2* expression correlates strongly with phenotype and may therefore represent the predominant GST that confers atrazine resistance in ACR and MCR.

EVALUATION OF CARRY OVER AND DRIFT WITH GROWTH REGULATING HERBICIDES IN *ARMORACIA RUSTICANA*. Kayla N. Wiedau*[1], Karla L. Gage[1], Ronald F. Krausz[2]; [1]Southern Illinois University, Carbondale, IL, [2]Southern Illinois University, Belleville, IL (145)

Horseradish is a broadleaf crop grown in high concentrations in the Mississippi River Vey area in St. Clair and Madison Counties, Illinois. Growers in this area are facing new risks with the pending introduction of transgenic soybean resistant to synthetic auxin herbicides, because horseradish is sensitive to this site-of-action. Increased applications as well as application timings of dicamba (3,6-dicholoro-2-methoxybenzoic acid) or 2,4-D (2,4-dicholorophenoxy), which could help growers gain control of herbicide-resistant weeds, also increase potential threats to sensitive crops. Applications could increase the risk of drift onto adjacent sensitive crops as well as carryover when in rotation with sensitive crops such as horseradish. However, the effects of dicamba and 2,4-D drift and dicamba carryover risk in horseradish production are unknown. Therefore, the objective of this research was to evaluate the risk of dicamba carryover to as well as dicamba and 2,4-D drift onto horseradish. Two separate field studies were established to complete these evaluations. The carryover evaluation was established as a two-year rotation of dicamba-tolerant soybean followed by horseradish. Results indicate no carryover concerns when dicamba is applied to soybean in-season at a 1x to a 4x rateand then rotated to horseradish with injury ratings at 0% at four, six, and eight wk after planting in both 2015 and 2016. In the simulated drift study horseradish was planted in 2015 and 2016 and owed to grow seven wk before six rates (1/10000, 1/1000, 1/100, 1/2, 1, and 2X) of dicamba or 2,4-D were applied (X = 0.5 lb ae $acre^{-1}$ dicamba, X = 0.95 lb ae $acre^{-1}$ 2,4-D). The focus was on rates of 1/10000, 1/1000, and 1/100X, which would represent likely non-target exposure rates in a drift event. Stand count was not reduced by any drift rate of either herbicide in either year. However, there was yield reduction by 29 to 100% in both years when 2,4-D was applied at the 1/1000X or greater rate. Yield reduction by 62.4 to 72.5% was observed in both years only when dicamba was applied at a 2X rate. Therefore, while concern may be minimal for dicamba drift or carryover, growers may need to take appropriate precautions in applications of 2,4-D near horseradish to avoid any non-target effects of drift.

MULTIPLE-RESISTANCE TO OXYFLUORFEN AND GLYPHOSATE IN DIFFERENT POPULATIONS OF RIGID RYEGRASS (*LOLIUM RIGIDUM*) FROM SPAIN. Pablo T. Fernandez-Moreno*[1], Julio Menendez[2], Reid Smeda[3], Rafael A. De Prado[1]; [1]University of Cordoba, Cordoba, Spain, [2]Department of Agroforestry Science, University of Huelva,, Huelva, Spain, [3]University of Missouri, Columbia, MO (146)

Integration of protoporphyrinogen oxidase (PPO)-inhibiting herbicides for weed control in perennial cropping systems in Spain resulted from selection of resistance to glyphosate (R) in several populations of rigid ryegrass (*Lolium rigidum* L.). In 2015, seeds of four populations (glyppo1, glyppo2, glyppo3, and glyppo4) of rigid ryegrass from different olive groves in southern Spain were collected. Each population had been treated with glyphosate at least 15 consecutive yr, and the last five yr, four of five populations treated with glyphosate + oxyfluorfen. One population (glyppo5) had only been treated with glyphosate 15 consecutive years. Seeds of a known PPO- and glyphosate-susceptible (S) rigid ryegrass population were collected from a nearby olive grove which had never received glyphosate or oxyfluorfen. Relative growth reduction (GR) and lethal doses (LD) were calculated at both 50 and 90% levels, resulting in a resistance index (RI; R-to-S) for glyphosate ranging from 14, 12, 10, 7, and 6 (GR_{50}) to 38, 29, 14, 13, and 12 (GR_{90}) for glyppo1, glyppo2, glyppo3, glyppo4, and glyppo5, respectively. For oxyfluorfen, the populations exhibited an RI ranging from 20, 18, 7, 6, and 1 (GR_{50}) to 70, 55, 13, 8, and 1 (GR_{90}) for glyppo1, glyppo2, glyppo3, glyppo4, and glyppo5, respectively. In the presence of 1000 µM glyphosate, shikimic acid accumulated in the S population to levels 197-, 159-, 10-, 7-, and 5-fold higher than in glyppo1 through glyppo5, respectively compared to untreated plants. At 100 µM oxyfluorfen, the accumulation of the photodynamic tetrapyrrole protoportphyrin IX (Proto IX) accumulated in the S-biotype 28-, 18-, 6-, 5-, and 1-fold higher levels compared to glyppo1, glyppo2, glyppo3, glyppo4, and glyppo5, respectively. Research is underway to identify the underling mechanisms that explain PPO resistance.

MULTIPLE RESISTANCE TO CHLORIMURON, FOMESAFEN, AND GLYPHOSATE IN PALMER AMARANTH FROM INDIANA. Douglas J. Spaunhorst*, William G. Johnson; Purdue, West Lafayette, IN (147)

Greenhouse experiments were conducted on four Palmer amaranth populations from Indiana to determine if chlorimuron, fomesafen, and glyphosate mixtures control multiple herbicide-resistant Palmer amaranth. Plants were genotyped for $Trp_{574}Leu$, ΔG210, and amplified 5-enolypyruvylshikimate-3-phosphase synthase (EPSPS) to determine if previously characterized mutations confer acetolactase synthase (ALS), protoporphyrinogen oxidase (PPO), and glyphosate resistance to Indiana Palmer amaranth, respectfully. Three-way herbicide-resistant Palmer amaranth control and biomass reduction was antagonized with mixtures of fomesafen plus glyphosate and chlorimuron plus fomesafen plus glyphosate. However, control of two-way herbicide-resistant Palmer amaranth with chlorimuron and glyphosate-resistant (GR) Palmer amaranth was additive with mixtures of chlorimuron plus glyphosate. herbicide mixtures provided 100% control of fomesafen or glyphosate-susceptible Palmer amaranth. The $Trp_{574}Leu$ mutation was not present in 36 to 100% of plants that survived treatment to chlorimuron. This suggests that different mutation(s) or mechanism(s) confer ALS resistance in Indiana Palmer amaranth populations. plants that survived treatment of fomesafen and glyphosate contained the ΔG210 deletion and had 18 or more EPSPS copies, respectively. Over, results from this study suggest three-way herbicide-resistant Palmer amaranth will be difficult for growers to control post-emergence in soybean, leaving glufosinate as the only post-emergence option for control of an Indiana Palmer amaranth population in soybean. However, chlorimuron and glyphosate mixtures provide more control of two-way resistant Palmer amaranth than chlorimuron or glyphosate alone. Mixtures of systemic herbicides are not antagonistic to ALS plus glyphosate or ALS plus PPO plus GR Palmer amaranth control. Mixtures of systemic plus contact herbicides are not recommended for control of ALS plus PPO plus GR Palmer amaranth.

EVALUATIONS OF HERBICIDE PROGRAMS IN ALS RESISTANT GRAIN SORGHUM. Eric A. VanLoenen*[1], Curtis R. Thompson[1], Anita Dille[1], Gary L. Cramer[2], Bruce V. Steward[3], Phillip W. Stahlman[4], Ken L. Carlson[5], Cathy L. Minihan[1], Alan J. Schlegel[6]; [1]Kansas State University, Manhattan, KS, [2]Kansas State University, Hutchinson, KS, [3]DuPont Crop Protection, Overland Park, KS, [4]Kansas State Research and Extension, Hays, KS, [5]DuPont Crop Protection, Johnston, IA, [6]Kansas State Univeristy, Tribune, KS (148)

DuPont Crop Protection has introduced new sorghum technology branded Inzen™ Sorghum. Inzen™ Sorghum contains an ALS-resistant gene introgressed from ALS-resistant shattercane found in southwest Kansas. This technology allows applications of sulfonylurea grass herbicide rimsulfuron applied preemergence (PRE) and nicosulfuron applied post-emergence (POST) for control of summer annual grass weeds. Field experiments were conducted at two Kansas State University research stations near Hutchinson and Manhattan, KS in 2015 and 2016. The research objective was to evaluate a range of possible herbicide programs for grass and broadleaf weed control and crop tolerance in Inzen™ Sorghum. Experiments were a randomized complete block design with four replications and had eleven treatments in 2015 and twelve in 2016. The experiments consisted of early pre-plant (EPP), PRE, and POST herbicide applications. The EPP treatment was rimsulfuron + thifensulfuron (1:1) applied at 63 g ha^{-1} two wk before planting in 2015 only. Six treatments received a PRE application of atrazine + S-metolachlor (1.292:1) applied at 2464 g ha^{-1}. Two of the six treatments also had rimsulfuron + thifensulfuron applied PRE at 63 g ha^{-1}. Eight treatments received POST herbicides. post treatments were applied with nicosulfuron at 35 g ha^{-1}, atrazine at 840 g/ha, crop oil concentrate at 1% v v^{-1} and ammonium sulfate at 2240 g ha^{-1}. The EPP and four PRE treatments were followed by a POST application previously described. Two POST treatments also included pyrasulfotole + bromoxynil (1:5.65) at 235 g ha^{-1}. Two different POST treatments included dicamba at 280 g a.e.ha^{-1}. In 2016 the EPP treatment was changed to a PRE treatment of rimsulfuron + thifensulfuron (2:1) applied at 26 g ha^{-1}. The added treatment in 2016 experiments was a POST treatment of atrazine + S-metolachlor + nicosulfuron applied at previous stated rates. Weed control and crop response were evaluated visuy at one, two, and four wk after POST treatment (WAPT). Treatments containing nicosulfuron and/or pyrasulfotole + bromoxynil caused 10 to 20% crop injury at one WAPT in both 2015 and 2016 at both locations. Treatments containing dicamba + nicosulfuron caused up to 30% injury and caused more injury in 2015 than in 2016. By four WAPT little to no injury was observed with any treatment indicating the grain sorghum recovered. In 2015 at the Manhattan location the nicosulfuron + atrazine only treatment controlled Palmer amaranth 64%, when tank mixed with dicamba or pyrasulfotole + bromoxynil, control ranged from 71 to 76%. When nicosulfuron + atrazine applied POST followed PRE of atrazine + S-metolachlor, Palmer amaranth was controlled 96 to 100%. In 2016 at the Hutchinson location, Palmer amaranth control was not adequate with atrazine + S-metolachlor applied PRE due to poor rainf activation. At both locations, nicosulfuron + atrazine provided 35, 55, and 61% control of large crabgrass, yellow foxtail and stinkgrass, respectively. Annual grass control ranged from 85 to 100% when nicosulfuron followed a PRE applied atrazine + S-metolachlor. These results were consistent in both Hutchinson and Manhattan in 2015. Herbicide programs for Inzen™ sorghum can provide adequate grass control, however an essential component of the total program includes the use of an effective grass and broadleaf herbicide applied PRE followed by a POST application of nicosulfuron tank mixed with an herbicide that effectively controls broadleaf weeds.

EFFECT OF SINGLE MODE OF ACTION POST-EMERGENCE HERBICIDES ON SEVERITY OF GOSS'S WILT IN CORN. Joseph T. Ikley*[1], William G. Johnson[2], Kiersten A. Wise[1]; [1]Purdue University, LAFAYETTE, IN, [2]Purdue University, West Lafayette, IN (149)

Goss's bacterial wilt and leaf blight of corn is caused by the bacterium *Clavibacter michiganensis* subsp. *nebraskensis* (Cmn). Goss's wilt has been identified in 17 states in the United States (U.S.) and has become an increasingly important disease over the last decade. Among corn diseases, Goss's wilt is currently the third-leading cause of yield loss in the US and Canada, with an estimated loss of 13 million metric tons between 2012 and 2015. The cause of the recent reemergence and spread of the disease is unknown, but has been attributed to an increase in hectares planted corn-on-corn, an increase in no-tillage practices, and wide-spread use of corn hybrids that are susceptible to Cmn. Other claims have been made that increased use of glyphosate in Roundup-Ready corn has led to an increase in Goss's wilt incidence. In 2014 and 2016, a field experiment was established at the Agronomy Center for Research and Education near West Lafayette, Indiana to determine if choice of single mode of action POST herbicide affected Goss's wilt severity. Six-row wide plots were established with the middle two rows containing a Cmn-susceptible corn hybrid and the outer four rows containing a Cmn-resistant hybrid. Only the middle two rows were inoculated with Cmn and the outer four rows served as borders to prevent the bacteria from spreading between plots. The middle two rows were inoculated at the V4 growth stage with a bacterial suspension containing 1 x 10^6 colony-forming units (CFU) of Cmn mL^{-1}. At the V6 growth stage, disease severity was measured on 10 plants $plot^{-1}$, then POST herbicide treatments were applied. Disease severity was measured on the same 10 plants $plot^{-1}$ every two wk until crop maturity to calculate the area under disease progress curve. After POST application, plots were kept weed free until crop maturity, and grain yield was collected. Means were separated using Fisher's least differences with a $P \leq 0.05$. In both years, there were no differences between treatments in either disease severity or crop yield. Results indicate that choice of POST herbicide has no effect on Goss's wilt severity in corn.

CRITICAL COVER CROP-FREE PERIOD IN CORN. Aaron P. Brooker*, Karen A. Renner, Christy L. Sprague; Michigan State University, East Lansing, MI (150)

Interseeding cover crops in corn during early vegetative growth stages may increase cover crop biomass and soil health benefits; however, cover crop competitiveness with corn, weed suppression, and herbicide influence on cover crop establishment must be understood. The objectives of this research were to evaluate (1) the competitiveness of annual ryegrass, crimson clover, and Tillage Radish® interseeded into corn from V1-V7, (2) weed suppression by interseeded cover crops, and (3) preemergence herbicide influence on cover crop establishment. In 2015, annual ryegrass, crimson clover, and Tillage Radish® were broadcast seeded into corn at the V1, V2, V3, V4, V5, and V6 growth stages at the Michigan State University Agronomy Research Farm in East Lansing, MI. In 2016, the same species were seeded at the V2, V3 V4, V5, V6, V7, and R6 corn stages. Glyphosate was applied prior to each interseeding at 0.84 kg a.e. ha^{-1}. Cover crop and weed densities were measured 30 d after cover crop planting; densities and biomass were measured again in October prior to corn grain harvest and the following spring for overwintering cover crops. A greenhouse experiment determined the effect of preemergence herbicides on cover crop emergence and growth. In 2015, cover crop density and biomass were genery higher for the V4-V6 interseedings compared with V1-V3 interseedings. In 2016, cover crop density and biomass were lower and more variable compared with 2015 due to a lack of rainf in June and early July. Weed density and biomass were greatest at V1 interseeding and less at later interseeding timings in 2015; in 2016 weed densities were greater and more variable. Corn yield was only reduced for the V1 interseeding timing in 2015; corn grain yield did not differ across interseeding timings in 2016. Annual ryegrass was not injured from saflufenacil and isoxaflutole applied at the standard rates of 75 and 105 g ha^{-1}, respectively. Crimson clover was tolerant of saflufenacil and pyroxasulfone at 75 and 180 g a.i. ha^{-1}, respectively, and dimethenamid-P + saflufenacil and isoxaflutole at ¼ of the standard rates. Tillage Radish® was tolerant of dimethenamid-P, saflufenacil, pyroxasulfone, and isoxaflutole at standard rates and tolerant of ½ of the standard rate of dimethenamid-P + saflufenacil. Interseeding cover crops at V2 or later in corn did not reduce grain yield in two years of research; saflufenacil can be applied to the cover crop species in this experiment with little to no injury. Other preemergence herbicides evaluated may be applied if only one or two of the cover crop species are interseeded.

INTERACTION BETWEEN HERBICIDES ON VOLUNTEER CORN (*ZEA MAYS* L.) CONTROL USING DIFFERENT NOZZLE TYPES. Marcella Guerreiro de Jesus*, Jeffrey A. Golus, Greg R. Kruger; University of Nebraska-Lincoln, North Platte, NE (151)

The management of glyphosate-resistant (GR) weeds and volunteer corn (*Zea mays*) is an ongoing chenge for growers in the U.S. The objective of this study was to evaluate the efficacy of clethodium (SelectMax) applied alone or in combination with dicamba (Clarity) to control volunteer GR corn. The study was conducted in a greenhouse at the Pesticide Application Technology Laboratory (PAT Lab) in North Platte, NE. Corn was grown at two different heights (15 cm and 30 cm) and treated with the following herbicide combinations: clethodim 0.0126 kg a.i. ha^{-1} and 0.0336 kg a.i. ha^{-1} , low rate of clethodim plus dicamba (0.0126 kg a.i ha^{-1} + 0.280 kg a.i. ha^{-1}), and high rate of clethodim plus dicamba (0.0336 kg a.i. ha^{-1} + 0.28 kg a.i. ha^{-1}). Plants were sprayed using a three nozzle laboratory track sprayer, where four nozzles were tested: XR11003, AIXR1103, TTI11003 and TT11003. The sprayer operating conditions were set a speed 20 kmh^{-1}, pressure of 276 kPa, application volume of 94 l ha^{-1} and 38 cm of nozzle spacing. The experiment was a factorial design with four solutions, four nozzles, two plant heights and four replications, which were organized in completely randomized design. At 28 d after application, plants were harvested and dry weight was recorded. Dry weight data were analyzed in SAS (PROC GLIMMIX), and when appropriate, means were separated using Fisher's LSD test and adjusted using a Tukey test. At the highest dose, clethodim applied to 30 cm tall corn with XR110003 was 88% which was more efficient than the same in combination with dicamba. With the AIXR 11003, 78% control was observed. Similarly, clethodium control of 15 cm tall corn sprayed with AIXR 11003 was 27% greater than clethodim + dicamba at the same dose. These data demonstrate that dicamba had an antagonistic effect on the control of volunteer GR corn.

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

MANAGING WATERHEMP IN SOYBEANS WITH LAYERED RESIDUAL HERBICIDES. A STRATEGY FOR CONTROLLING HERBICIDE RESISTANT WATERHEMP IN MINNESOTA.
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The objective of this trial was to evaluate and demonstrate the effectiveness of layering soil residual herbicides for control of waterhemp in soybeans in southeastern Minnesota. Tall waterhemp *(Amaranthus tuberculatus)* is becoming more widespread throughout Minnesota. Most waterhemp populations in Minnesota are resistant to ALS (Group 2) herbicides. In 2007, waterhemp populations resistant to glyphosate (Group 9) were reported and in 2015 and 2016, waterhemp populations in southern Minnesota were confirmed resistant to PPO herbicides (Group 14), with some populations resistant to both Group 9 and Group 14. New management strategies to control waterhemp are needed. One strategy for dealing with glyphosate-, PPO- and ALS-resistant waterhemp is to layer soil residual herbicides (Group 15), preemergence (PRE) followed by additional residual herbicide (Group 15) at early post-emergence (POST), about 30 days after planting. Waterhemp seedlings emerge over an extended period of time, frequently outlasting the effective residual control achieved by herbicides applied before or at crop planting. Several residual herbicides may be applied post-emergence to the crop alone or in combination with other post-emergent herbicides. When activated by rainfall, these post-applied residual herbicides can extend the duration of waterhemp seedling control. Three herbicides were evaluated in this study in 2015 and 2016, 1) s-metolachlor at 1600 g a.i. ha^{-1} PRE only or 1600 g a.i. ha^{-1} PRE followed by 1070 g a.i. ha^{-1} POST, 2) dimethenamid-P at 940 g ai ha^{-1} PRE only or 736 g a.i. ha^{-1}PRE followed by 525 g a.i. ha^{-1} POST, and 3) acetochlor at 1350 g a.i. ha^{-1} PRE only or 1350 g a.i. ha^{-1} PRE followed by 1350 g a.i. ha^{-1}POST. These were selected because of their known effectiveness for controlling waterhemp and their flexibility of application timing. Rates used were based on soil type and seasonal limits. The waterhemp population at Rochester is ALS (Group 2) resistant. Imazethapyr in 2015 and chloransulam in 2016 were used preemergence to assist in controlling other broadleaf weeds present in this study. A randomized complete block design was used with three replications. Preemergence treatments were applied at planting on May 5, 2015 and May 4, 2016. Layered soil residual products were applied post-emergence, 34 d (2015) and 29 d (2016) after preemergence herbicides were applied. Evaluations of the plots were taken from May through September. Layered or sequential applications of Dual II Magnum, Outlook, or Warrant herbicide provided better, (95, 94, and 90%, respectively) season-long control of waterhemp compared to their PRE only treatments (81, 71, and 62%, respectively) at the September 29, 2015 rating. The results were similar in 2016 with Dual II Magnum, Outlook and Warrant providing better (94, 95 and 91%, respectively) season long control of waterhemp compared to their PRE only treatments (76, 79, and 79%, respectively) at the September 26, 2016 rating. The performance of these herbicides applied PRE correlates with their half-life, (average 30 d) as control starts to diminish about 30 d after application. This illustrates the need for additional weed management strategies to achieve season-long control of herbicide-resistant waterhemp.

UTILITY OF ELEVORE™ HERBICIDE WITH ARYLEX ACTIVE™ FOR PREPLANT BURNDOWN APPLICATIONS.
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Elevore is a new herbicide being developed for the U.S. pre-plant burndown market segment for control of horseweed [*Conyza canadensis(L.) Cronq]* and other problematic broadleaf weeds. It contains Arylex™ active (halauxifen-methyl), a novel synthetic auxin (WSSA group 4) herbicide from the new "arylpicolinate" chemical class. Elevore is a SC formulation with a use rate of 1.0 fl oz product acre^{-1} [Arylex (halauxifen-methyl 5.0 g a.e.ha^{-1})] and will be labeled for use prior to soybean, corn and cotton planting. Initial labeling will ow application up to 14 d prior to planting of soybean and corn. Field research was conducted from 2013 to 2016 at 30 locations across the U.S. to determine the efficacy of Elevore applied in the spring to horseweed, including glyphosate-resistant biotypes, and other common weeds prior to planting soybean and corn. Elevore was compared to competitive standards when applied with glyphosate and in tan- mixtures with glyphosate + 2,4-D low volatile ester (LVE) herbicide. Applied at 5.0 g a.e.ha^{-1} in combination with glyphosate at 1120 g a.e.ha^{-1}, Elevore demonstrated similar to or better control of horseweed when compared to Liberty (glufosinate) at 542 g a.e.ha^{-1}, Clarity (dicamba) at 280 g a.e.ha^{-1} + glyphosate 1120 g a.e.ha^{-1}, and Sharpen (saflufenacil) at 37.5 g a.i.ha^{-1}+ glyphosate at 1120 g a.e.ha^{-1}. Crop injury was evaluated in efficacy trials as well as dedicated weed-free crop tolerance trials. Soybean and corn can be planted 14 d after application of Elevore without injury. Elevore will provide growers with an alternative mode-of-action for many difficult to control pre-plant burndown broadleaf weeds such as horseweed and henbit (*Lamium amplexicaule L)*.

AN INTRODUCTION TO ZIDUA PRO HERBICIDE FOR SOYBEAN. Duane P. Rathmann[1], Brady F. Kappler[2], Jared M. Roskamp*[3], Gery S. Welker[4], Vince M. Davis[5]; [1]BASF, Waseca, MN, [2]BASF, Eagle, NE, [3]BASF, Sutter, IL, [4]BASF, Fishers, IN, [5]BASF, Verona, WI (156)

Preplant/preemerge herbicides have had value in soybean weed control programs for decades. With several new soybean systems being implemented into the market, including dicamba-tolerant and 2,4-D-tolerant soybeans, use of preplant/preemerge herbicides will still play an important role in a successful weed control system. BASF has developed Zidua PRO as an effective and long lasting preplant/preemerge herbicide for use in soybeans. This herbicide contains three active ingredients to provide a solid start for weed control in any soybean system. Zidua PRO contains saflufenacil, imazethapyr, and pyroxasulfone (WSSA groups 14, 2, and 15 respectively). This herbicide provides residual control on a wide spectrum of grass and broadleaf species with burndown control of many broadleaves and some grass species. Field trials were conducted in 2016 to evaluate burndown and residual weed control as well as crop safety as compared to commercial standards. Results show that Zidua PRO applied alone and in a systems approach with other herbicides can control a broad spectrum of weeds in soybean including glyphosate resistant species such as waterhemp and Palmer amaranth.

A NEW S-METOLACHLOR PLUS DICAMBA PREMIX AS AN EFFECTIVE TOOL IN AN INTEGRATED WEED MANAGEMENT PROGRAM IN DICAMBA TOLERANT SOYBEANS. Brett R. Miller*[1], Adrian J. Moses[2], Don J. Porter[3], Timothy L. Trower[4], James C. Holloway[5]; [1]Syngenta, Minnetonka, MN, [2]Syngenta, Gilbert, IA, [3]Syngenta, Greensboro, NC, [4]Syngenta, Baraboo, WI, [5]Syngenta, Jackson, TN (157)

A new low volatility premix formulation of *S*-metolachlor plus dicamba is under development by Syngenta Crop Protection for weed control in dicamba-tolerant soybeans and cotton. The dual site-of-action herbicide is designed to deliver pre- and post-emergence activity as a burndown, pre-emergence or early post-emergence application. Field trials were conducted in 2015 and 2016 to evaluate weed control efficacy and crop safety of this new herbicide as part of an integrated weed management program in dicamba-tolerant soybeans. The *S*-metolachlor plus dicamba formulation provides post-emergence control of many important weed species including horseweed, common and giant ragweed and common lambsquarters. It also provides post-emergence and residual control of *Amaranthus* species and residual control of many annual grass weeds. Successful and consistent weed control in dicamba-tolerant soybeans are targeted with programs that include an effective burndown, pre-emergence residuals and post-emergence herbicides with multiple, overlapping sites-of-action. *S*-metolachlor plus dicamba will be an important herbicide tool as part of an integrated weed management program for dicamba-tolerant soybeans.

THE VALUE OF USING A SYSTEMS APPROACH WITH ENGENIA HERBICIDE IN DICAMBA TOLERANT SOYBEANS. Brady F. Kappler[1], Jared M. Roskamp[2], Vince M. Davis*[3], Gery S. Welker[4], Duane P. Rathmann[5]; [1]BASF, Eagle, NE, [2]BASF, Sutter, IL, [3]BASF, Verona, WI, [4]BASF, Fishers, IN, [5]BASF, Waseca, MN (158)

Engenia herbicide is a new low volatile BAPMA salt formulation of dicamba specificy designed for use on dicamba tolerant soybean. Engenia is a 5 lb per gal acid equivalent formulation which will ow for a use rate of 12.8 oz/a to deliver the 0.50 lb per acre use rate for post applications in dicamba tolerant soybeans. Trials were conducted across the midwest in 2016 to evaluate the performance of complete program using soil residual products such as Zidua PRO followed by an early post application of Engenia plus glyphosagte with and with a post residul product such as Outlook. For complete weed control of broadleaf weeds such as giant ragweed and common ragweed, a soil applied pre product was necessary and in the case of amaranthus species, the addition of a post residual product was also needed. It is clear that a systems approach using soil applied pre herbicides followed by a timely application of Engenia plus glyphosate will be necessary to achieve complete weed control and will help reduce the chance of weed resistance development in dicamba tolerant soybeans. The addtion of a post applied residual with Engnenia plus glyphosate will be necessary to control later germinating weeds such as waterhemp and palmer amaranth.

EVALUATION OF LACTOFEN PLUS GLUFOSINATE TANK-MIXES IN GLUFOSINATE TOLERANT SOYBEAN. Eric J. Ott*[1], Dawn E. Refsell[2], Lowell D.

Sandell[3], Ronald E. Estes[4], Trevor D. Israel[5], John A. Pawlak[6]; [1]Valent USA Corporation, Greenfield, IN, [2]Valent USA Corporation, Lathrop, MO, [3]Valent USA Corporation, Lincoln, NE, [4]Valent USA Corporation, Champaign, IL, [5]Valent USA Corporation, Sioux Fs, SD, [6]Valent USA Corporation, Lansing, MI (159)

Herbicide-resistant weeds continue to be a problem in soybean production. Glyphosate resistance has been identified in several important weed species, and continues to increase across major soybean growing regions. In response, growers have adopted or are considering adopting different herbicide resistant trait technologies, such as glufosinate tolerant soybean. Glufosinate-tolerant soybean production has dramaticy increased in the past several years due to the need to control glyphosate resistant weeds. However, very little is known about glufosinate tank-mixtures with PPO inhibiting herbicides. Trials were initiated across the major soybean growing regions in the Midwest and Mid-south in 2016. In these trials glufosinate resistant soybeans were utilized. Weeds were owed to grow to approximately 15 cm in height and then treated with different glufosinate and PPO herbicide tank-mixtures. These treatments included; a non-treated check, glufosinate 594 g a.i.ha^{-1}, glufosinate 594 g a.i. ha^{-1} + lactofen 140 g a.i. ha^{-1} +/- COC 0.83% v v^{-1}, glufosinate 594 g a.i. ha^{-1} + lactofen 175 g a.i. ha^{-1}, glufosinate 594 g a.i. ha^{-1} + lactofen 219 g a.i. ha^{-1}, glufosinate 594 g a.i. ha^{-1} + fomesafen 263 g a.i. ha^{-1} + COC 0.83% v v^{-1}, and glufosinate 594 g a.i. ha^{-1} + acifluorfen 280 g a.i. ha^{-1} + COC 0.83% v v^{-1}. herbicide treatments included AMS 3.35 kg ha^{-1} per the glufosinate label. Crop phytotoxicity was visuy evaluated at 7 DAT and between 14 and 21 DAT. Weed control was also visuy evaluated 7, between 14 and 21 DAT and 21 to 35 DAT. Adding lactofen to glufosinate did increase control of common ragweed, giant ragweed, common waterhemp, and Palmer amaranth. In these trials, tank-mixtures of glufosinate and PPO-inhibiting herbicides did not result in a reduction of grass control relative to glufosinate alone. Typical phytotoxic responses were observed in treatments that included PPO-inhibiting herbicides. However, at 21 DAT glufosinate + PPO-inhibiting herbicides exhibited <5% crop phytotoxicity. These trials indicate that including lactofen in tank-mixtures with glufosinate does increase weed control on certain problematic weeds compared to glufosinate 594 g a.i.ha^{-1} alone.

WEED CONTROL IN THE XTEND CROP SYSTEM. Ryan J. Rector*; Monsanto, St. Louis, MO (160)

HERBICIDE STRATEGIES FOR PALMER AMARANTH MANAGEMENT IN ILLINOIS. Lanae Ringler*; University of Illinois, Urbana, IL (161)

Palmer amaranth (Amaranthus palmeri) is a dioecious summer annual broadleaf species that originated in the southwestern United States, but has been expanding into the Midwest in recent years. Research has indicated that Palmer amaranth establishment in Illinois is limited only by seed introduction. Concerns exist about the extent of damage Palmer amaranth could inflict upon Illinois agronomic crops and what herbicide options are effective for its control. Three field experiments were conducted during 2015 and 2016 to characterize and differentiate effective herbicides for Palmer amaranth control in Illinois. Soil-residual soybean herbicide combinations were evaluated to determine their duration of Palmer amaranth control or suppression. In another trial, post-emergence herbicides from five site-of-action groups were applied at three timings based on Palmer amaranth height to determine the growth stage at which each herbicide was most effective. Field dose-response experiments evaluated the response of Palmer amaranth to two synthetic auxin herbicides, each applied at nine rates in a third trial. Results indicated less Palmer amaranth biomass accumulated when soil-residual herbicides were applied prior to application of a post-emergence herbicide compared with treatments of only post-emergence herbicides. Analysis of biomass suggests a correlation between the herbicide efficacy and Palmer amaranth size when herbicide is applied, however, control was incomplete for some herbicides regardless of growth stage. Results also indicate that synthetic auxin herbicides should be applied at labeled rates to achieve acceptable Palmer amaranth control.

FACTORS INFLUENCING OFF TARGET MOVEMENT OF NEW HERBICIDE FORMULATIONS. David M. Simpson*[1], Jerome J. Schleier, III[2], Mei Li[1], David G. Ouse[1], James M. Gifford[1]; [1]Dow AgroSciences, Indianapolis, IN, [2]Dow AgroSciences LLC, Indianapolis, IN (162)

Soybean herbicide resistance traits that provide tolerance to 2,4-D or dicamba have been developed by Dow AgroSciences and Monsanto. Both 2,4-D and dicamba are potentiy susceptible to volatility and vapor drift. Volatility of 2,4-D and dicamba is genery directly correlated to the volatility of the associated counter-ion. For example, laboratory and field studies conducted by Dow AgroSciences have demonstrated that the non-volatile choline cation provides a reduction in volatility of 2,4-D even compared to the dimethylammonium (DMA) salt. Similarly, BASF has shown reduction in volatility with the N,N-Bis-(3-aminopropyl)methylamine (BAPMA) salt of dicamba compared to the DMA and diglycolamine (DGA) salts. Historicy, vapor pressures of the herbicides have been used to compare relative volatility potential. However, these auxinic herbicides will be applied to plant and soil surfaces and rarely applied as simple herbicide salt solutions. Tank-mixes as well as pre-mixes of 2,4-D or dicamba with glyphosate for broad-spectrum weed control are and will continue to be common. Applications will often include the addition of water conditioning agents such as ammonium sulfate (AMS) or AMS replacements. It is important to understand the impact of spray solution properties on the volatility of auxinic herbicides from soil and plant surfaces. The effect of glyphosate, spray solution pH and the presence of other counter-ions on the volatility of 2,4-D and dicamba were determined in controlled laboratory studies. Treatments were applied to corn and volatility measured over a 96 hr period after application. Addition of glyphosate did not increase volatility of 2,4-D choline, but did increase volatility of dicamba DGA and dicamba BAPMA. Volatility was increased when AMS was added to glyphosate + dicamba

DGA or dicamba BAPMA. Volatility of 2,4-D choline + glyphosate was not affected by the addition of AMS. Volatility of dicamba increased as the pH of the spray solution decreased. It is imperative that spray solution pH and adjuvants, water conditioning agents, and other pesticide products be considered when determining the volatilization potential of dicamba. In contrast, volatility of 2,4-D choline was not affected by these factors.

CONTROL OF GLYPHOSATE RESISTANT CANADA FLEABANE IN CORN/SOYBEAN/WHEAT ROTATION. Peter H. Sikkema*, Nader Soltani; University of Guelph, Ridgetown, ON (163)

Glyphosate-resistant (GR) *Conyza canadensis* (Canada fleabane) was first reported in Ontario, Canada in 2010 when it was found on 8 farms in one county. Over four years it has spread to 25 counties over a distance of greater than 800 km. Multiple resistant (Group 2 and 9) *Conyza canadensis* has been documented on more than 10% of affected farms. *Conyza canadensis* is an extremely competitive weed and lack of control in corn, soybean and wheat can lead to yield losses. More than 50 field experiments were conducted during 2011-2015 to determine the best herbicide options (among registered herbicides in Ontario) for the control of GR *Conyza canadensis* in corn, soybean and wheat. experiments were arranged in a completely randomized block design with four replications. Among corn preplant herbicides evaluated, dicamba, dicamba/atrazine, mesotrione+atrazine and saflufenacil/dimethenamid-P 88, 94, 89 and 91% control of GR *Conyza Canadensis*, respectively. Among corn POST herbicides evaluated, dicamba, diflufenzopyr/dicamba, dicamba/atrazine and bromoxynil + atrazine provided 96, 91, 96 and 91% control of GR *Conyza Canadensis*, respectively. The best herbicide option for enhanced burndown of GR *Conyza Canadensis* in soybean was glyphosate plus saflufancil which provided 77% control. In winter wheat, 2,4-D, dicamba, dicamba/MPCA, dicamba/MPCA/mecoprop-P, clopyralid and pyrasulfotole/bromoxynil provided 89, 91, 94, 92, 96 and 92% control of GR *Conyza Canadensis*, respectively. Based on these results, an integrated weed management program which employs a three crop rotation and multiple herbicide modes-of-action can be used for commerciy acceptable control GR *Conyza Canadensis* in corn, soybean and winter wheat.

TALINOR™ HERBICIDE: INTRODUCING A NEW POST-EMERGENCE HERBICIDE FOR BROADLEAF WEED CONTROL IN CEREALS. Aaron S. Franssen*[1], Pete C. Forster[2], Don J. Porter[3], Monika Saini[4]; [1]Syngenta Crop Protection, Pleasant Dale, NE, [2]Syngenta Crop Protection, Eaton, CO, [3]Syngenta, Greensboro, NC, [4]Syngenta Crop Protection, Greensboro, NC (164)

Syngenta is developing Talinor™ herbicide, a new selective post-emergence herbicide for the US market that will provide broad-spectrum broadleaf weed control in wheat and barley. Talinor contains two active ingredients with multiple modes-of-action: Bicyclopyrone, on HPPD-inhibitor (Site-of-action Group 27) and Bromoxynil, a PS II-inhibitor (Site-of-action Group 6). In field trial experiments conducted over multiple years, Talinor at 212.5-283.3 g a.e.ha $^{-1}$combined with CoAct+™ additive at 64-84 g a.i. ha^{-1} provided excellent control of some of the more troublesome broadleaf weeds in cereals, such as Russian thistle, kochia, wild buckwheat, prickly lettuce and mayweed chamomile, including those populations that are resistant to ALS-inhibitor and synthetic auxin herbicides. Talinor has shown excellent crop safety to tested varieties of spring wheat, durum, winter wheat and barley and can be applied from the 2-leaf stage to the pre-boot stage of the crop. Talinor can be tank mixed with graminicides such as Axial® brands for one-pass grass and broadleaf weed control. Syngenta anticipates receiving EPA approval in time for a 2017 launch of Talinor.

JOHNSONGRASS (*SORGHUM HALEPENSE*) DEMOGRAPHY IN RESPONSE TO DIFFERENT HERBICIDE PROGRAMS. Don G. Treptow*; University of Nebraska - Lincoln, Ithaca, NE (165)

Understanding how different herbicide programs affect Johnsongrass demographics can help in devising strategies to effectively control this weed. It will also enable a model for herbicide resistance evolution in Johnsongrass to be developed. The effects of different herbicide programs on ALS-susceptible and resistant Johnsongrass demographic parameters were examined. A field experiment was conducted at the UNL – Agricultural Research and Development Center near Mead, NE and at the UNL – Havelock Farm, Lincoln, NE. 32 two by two m plots were established at each site in the summer of 2015. In each plot, 16 Johnsongrass plants were transplanted into a uniform pattern. A one x one m PVC frame was placed in the center of the plot. Aboveground demographic data was collected from inside the 1 m^{-2} area over the course of the study, and belowground demographic data from adjacent areas within the experimental plot. The experiment was conducted using a split-design where Johnsongrass population was treated as the whole plot factor and herbicide treatment was the subplot. Whole plot consisted of two levels, ALS-susceptible Johnsongrass and ALS-resistant Johnsongrass. Subplot herbicide treatments consisted of four levels, continuous use of nicosulfuron, nicosulfuron fb glyphosate in alternating years, glyphosate burndown with post nicosulfuron, and no herbicide control. The study was conducted on a randomized complete block design with four replications. Throughout the f, seeds were collected from the plots to estimate seed production and subsequently tested for germinability and total viability. In the f of each year, total number of culms were counted within the one m^{-2} area. Aboveground biomass was also collected for dry weight determination. Soil cores were collected from each plot to quantify the demography of rhizomes. These studies ow for an estimate of fresh bud viability, overwinter survival, emergence window, within season survival, and the influence of different herbicides on rhizome demographics.

EFFECT OF FORMULATION ON PYROXASULFONE DISSIPATION IN A WHEAT FIELD SOIL ENVIRONMENT. Thomas C. Mueller*; University of Tennessee, Knoxville, TN (166)

Weed control in wheat has been chenged by resistance development to several commonly used herbicide modes-of-action. Pyroxasulfone is a herbicide that inhibits very long chain fatty acid synthesis and may be used to control ryegrass and other weeds in wheat. This molecule is somewhat unique because it is sold by three different companies with three different formulations. The objective of the study was to determine what effect, if any, the different formulations had on pyroxasulfone dissipation in a winter wheat production system. Field plots (3 x 10 m) were established in Knoxville, Tennessee in the F of 2014 and 2015, with three sets of studies conducted with initial applications on September 30 and October 22, 2014 and on October 26, 2015. The dosage of each herbicide was 100 g a.i. ha^{-1} pyroxasulfone. Treatments included an EC formulation (trade name Anthem), a dry formulation of pyroxasulfone alone (Zidua), and a dry formulation that also included flumioxazin (Fierce). Commercial herbicide formulations were applied in 190 l ha^{-1} of water carrier using flat fan nozzles and sm plot spray equipment. Soil samples were collected from 0 to 10 cm depth immediately after each herbicide application, and at approximately weekly intervals for seven wk. At the end of the sampling interval soil temperatures were at or near freezing, thus soil sampling was not possible and it was probable that pyroxasulfone dissipation was minimal. A soil sample was taken the following spring for analysis. After collection soil samples were frozen until later analysis which consisted of methanol extraction of 40 g of moist soil followed by analysis using LC MS. Pyroxasulfone concentrations were compared to external standards prepared from analytical pyroxasulfone. The concentrations were regressed to fit a simple first order regression equation using SigmaPlot 12.5 software. This regression analysis produced a first-order rate constant which was then used to calculate a half-life in d for each respective dissipation curve. Half-lives range from 15 to 52 d with an over average of 31 d. Half-lives averaged over the three data sets indicated no affect of formulation on differential dissipation of pyroxasulfone.

THE EFFECTS OF INCREASING RATES OF DICAMBA FOR PALMER AMARANTH CONTROL IN FOW. Rand S. Currie*[1], Ivan B. Cuvaca[2], Mithila Jugulam[3]; [1]Kansas State Univ., Garden City, KS, [2]Kansas State Univ., Garden city, KS, [3]Kansas State University, Manhattan, KS (167)

Many factors have increased the frequency of dicamba usage which has greatly exacerbated selection pressure for dicamba resistance in Palmer amaranth. As kochia and Palmer amaranth have expressed wide-spread resistance to glyphosate, growers have increasingly begun to rely on dicamba for postemergence and preemergence weed control. Growers in southwestern Kansas for the last several years have relied heavily on preemergence applications of dicamba applied in late February and early March as a price competitive effective method to control kochia. This is often followed by late May or June applications of dicamba or a tank-mixture containing some rate of dicamba. Safeners that protect grass crops from dicamba injury as well as the emergence of dicamba-resistant soybeans and cotton have produced nearly season-long potential selection pressure. Tehranchian and Norsworthy (2016 Proc. WSSA) have shown in greenhouse studies that Palmer amaranth can evolve enhanced tolerance to dicamba with sub-lethal doses in only three generations. Therefore, it was the objective of this research was to establish under field conditions a dose-response curve in a naturally occurring population of Palmer amaranth to try to document methods to monitor the development of dicamba resistance. In mid-July near Garden City, Kansas a naturally occurring uniform stand of Palmer amaranth was selected. On July 20, 2016 a randomized complete block experiment was established with six levels of dicamba applied to four replicates. Dicamba was applied to three x nine m plots at 70,140,210,280,420 or 560 g ha^{-1} (2, 4, 6, 8, 12 or 16 oz. of formulated product (OFP)) plus 0.25% v v^{-1} nonionic surfactant in a carrier volume of 25 L ha-1. Palmer amaranth height ranged from 4 to 42 cm. Palmer amaranth biomass was harvested August 17, 2016 and oven dried. Analysis of variance and simple linear and curvilinear models were then tested. Polynomial models explained declines in fresh and dry weights with increasing levels of dicamba very well with R-squares of 0.91 and 0.89, respectively. The curvilinear nature of the response was primarily between the control and the lowest dicamba rate. Rates lower than 70 g ha^{-1} are impractical and seldom if ever used. It is fortuitous that the portion of the curves from 70 to 560 g ha^{-1} were linear with R-squares of 0.94 and 0.96 for fresh and dry weights, respectively. These linear models allow for simple presentation of the response with in the practical use rates of dicamba. Fresh weights decline 3% for each OFP from 52% at 2 OFP to 97% at 16 OFP. Dry weights decline 2.8 % for each OFP from 50 % at 2 OFP to 91% at 16 OFP. Although at the highest dicamba rate Palmer amaranth was severely injured, it did not completely die. It appears that percent moisture was a predictor of this degree of injury. Moisture dropped from 85% in the control to 52% at the highest rate of dicamba and this decline was well described by the equation: percent moisture=0.9 X OFP- (OFP squared X 0.18) +84. These models should help others design future experiments to measure dicamba resistance. Also it seems possible that in addition to dicamba resistance evolving at low doses as reported by Tehranchian and Norsworthy, it might also evolve by applying high rates of dicamba to Palmer amaranth larger than 40 cm. Although 280g ha^{-1} application of dicamba has long been used to provide excellent control of Palmer amaranth smaller than 20 cm in canopies of corn and sorghum, in fallow situations with plants larger than 20 cm tank mix partners are will be needed.

EVALUATION OF HERBICIDE TREATMENTS FOR THE TERMINATION OF COMMON COVER CROP SPECIES. Derek M. Whalen*[1], Mandy D. Bish[2], Jason Norsworthy[3], Shawn Conley[4], Bryan Young[5], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO, [3]University of Arkansas, Fayetteville, AR, [4]University of Wisconsin, Madison, WI, [5]Purdue University, West Lafayette, IN (168)

The use of cover crops has increased in Midwestern crop production in recent years. There are many questions surrounding cover crops, specificy their benefits to crop production systems and how to best manage them. One management aspect to consider is how to effectively terminate cover crops in the spring before planting the intended cash crop. Few studies have been conducted to evaluate the effect of different herbicide treatments on the termination of various cover crop species in the spring. Identical field experiments were conducted in 2016 in Arkansas, Indiana, Missouri and Wisconsin to evaluate the most effective herbicide treatments for spring termination of regiony-specific cover crops, including Austrian winter pea, cereal rye, crimson clover, hairy vetch, Italian ryegrass, purple top turnip, triticale and wheat. Cover crop species were planted from September 4th to September 24th in 2015. Glyphosate-, glufosinate-, and paraquat-based treatments were sprayed between April 15th and April 23rd in 2016. Visible control of cover crops ratings was taken 14 and 28 d after application (DAT) and fresh weight biomass reduction were determined 28 d after application. Data was subjected to analysis using the PROC GLIMMIX procedure in SAS and means were separated using Fisher's Protected LSD ($P \leq 0.05$). Cereal rye and Italian ryegrass were evaluated at four sites. Glyphosate-based herbicide programs were genery more consistent on cereal rye when comparing 28 DAT visual control ratings to glufosinate- or paraquat-based programs across the four sites. Five of the seven glyphosate programs tested (glyhopsate plus dicamba, glyphosate plus saflufenacil, glyphosate plus 2,4-D, glyphosate plus 2,4-D plus sulfentrazone plus chlorimuron, and glyphosate plus 2,4-D plus metribuzin) resulted in 98.8% to 100% visual control and were statisticy higher than other treatments analyzed with the exception of glyphosate plus clethodim (93.8% control) and glyphosate alone (93.7% control). Glyphosate plus saflufenacil resulted in the highest biomass reduction, 71.2% of the non-treated control; this was statisticy similar to biomass reductions of glyphosate- and paraquat-based treatments with the exception of glyphosate plus 2,4-D (55.1%). For Italian ryegrass, glyphosate plus clethodim was the only program that achieved greater than 90% control over four sites (93.8%). It was statisticy similar to glyphosate plus saflufenacil (88.8%) but ly higher than other programs tested. Glufosinate control of cereal rye and Italian ryegrass varied by region. Hairy vetch was studied at 3 locations and in general, was more consistently controlled than the grass species. Of the 18 herbicide programs tested, 15 achieved greater than 90% visual control. Glyphosate alone, glyphosate plus clethodim, and paraquat achieved 82.8%, 81.8%, and 78.7% respectively. Results from this study, including the data from the other five cover crops analyzed, show that herbicide selection is very crucial when terminating cover crops in the spring.

EXPLORING THE MONSANTO TRAIT DEVELOPMENT PROCESS BY WAY OF DICAMBA AND GLUFOSINATE TOLERANT CORN EVENT MON 87419. Michael Goley*[1], Jintai Huang[1], Oscar Sparks[1], Aihua Shao[1], Martin Stoecker[1], Mark Groth[2], Tracy Klingaman[1], Susan Martino-Catt[2], Rita Varagona[1]; [1]Monsanto Company, Chesterfield, MO, [2]Monsanto Company, Creve Coeur, MO (169)

Monsanto is developing dicamba- and glufosinate-tolerant corn event MON 87419 for commercialization by the end of the decade. This presentation will focus on the early development process (Phase 2) from transformation to the selection of commercial event MON 87419. Rigorous molecular characterization, event selection, and field testing resulted in an event with exceptional herbicide tolerance and agronomic equivalence. The Phase 2 processes are designed to not only demonstrate trait performance, but also ensure safety and minimize the risk of unintended effects.

STEWARDSHIP: WHAT IS OUR ROLE? Arlene Cotie*; Bayer CropScience, Research Triangle Park, NC (170)

PALMER AMARANTH: UNINVITED GUEST TO CONSERVATION PLANTINGS. Bob Hartzler[1], Meaghan J. Anderson*[2]; [1]Iowa State University, Ames, IA, [2]Iowa State University, Iowa City, IA (171)

Prior to 2016, Palmer amaranth was identified in five counties along Iowa's state borders with Nebraska, Missouri, and Illinois. Although the precise means of introduction were not identified, evidence suggests that traditional agricultural practices and commercial grain handling were involved at these sites. Casual scouting suggested that Palmer amaranth was not spreading from the initial sites of infestation. By the end of the 2016 growing season, Palmer amaranth had been confirmed in 48 Iowa counties, and we suspect it is present in many more. While some of the new introductions were associated with common agricultural practices, the majority were due to planting of native seed mixes contaminated with Palmer amaranth. In 2016 a tremendous increase in planting of native seed mixes occurred across Iowa due to government programs like the Conservation Reserve Program (CRP). Pollinator habitat (CP42) was one of the more popular programs due to cost share for establishment, signing incentives, and annual rental payments competitive with cash rent rates. Other programs such as wildlife food plots, native grass and forb plantings, and permanent wildlife habitat also encouraged planting of native seed mixes. In Iowa, over 200,000 acres were planted with native seeds in 2016, and many counties had between 100 and 200 fields entered into these programs. In mid-July, we received the first two reports of Palmer amaranth in new conservation plantings. One of these sites was wildlife habitat (CP33) whereas the other was pollinator habitat. Due to the expertise of the two landowners and the random distribution of Palmer amaranth within the fields, we were confident the Palmer amaranth was not present in the fields prior to establishment of the new conservation planting in the spring of 2016. Since publicizing the concern over Palmer amaranth infesting conservation plantings, Palmer amaranth has been found in conservation plantings in over 35 counties across Iowa. Contamination of native seed mixes with Palmer amaranth seed is the primary means of Palmer amaranth introduction in conservation plantings. We, and several other states, have separated *Amaranthus* spp. seed from different seed mixes and positively identified them as Palmer amaranth by growing plants from the seed in the greenhouse. We visited the largest Iowa producer of native seeds, inspected their production fields, and were unable to find Palmer amaranth. With cooperation from Iowa native seed producers, we've learned that high demand for native mixes resulted in purchase of several species from out-of-state vendors. The producers believe that these imported seed were the source of the Palmer amaranth. One Iowa producer supplied us with a bag of side-oats grama purchased from Kansas suspected to be a source of Palmer amaranth. We have separated *Amaranthus* spp. seed from this bag, but have yet to confirm its identity. Introduction of Palmer amaranth via contaminated native seed has occurred in other states as well. Ohio documented contaminated seed native seed mixes as a problem in 2014; the native seed contaminated with Palmer amaranth was imported from Texas. Both Illinois and Minnesota identified new conservation plantings this summer where Palmer amaranth was introduced, but the number of new introductions in those states appear to be a fraction of that in Iowa during 2016.

A SEASON TO REMEMBER: OUR EXPERIENCES WITH OFF-TARGET MOVEMENT OF DICAMBA IN MISSOURI. Kevin W. Bradley*; University of Missouri, Columbia, MO (172)

In 2016, the majority of the cotton acreage in the southeastern portion of Missouri was planted with dicamba-tolerant (DT) varieties. A limited number of DT soybean varieties were also planted throughout the state. However, during the 2016 growing season, the Environmental Protection Agency had not approved any dicamba herbicide formulations for post-emergence application to DT cotton or soybean. Although investigations are ongoing, apparently a subset of growers made illegal applications of dicamba to their DT cotton and/or soybean, which resulted in off-target movement of dicamba to a variety of sensitive crops, including large acreages of non-DT soybean. In southeastern Missouri alone, over 125 dicamba injury complaints were filed with the Missouri Department of Agriculture. These injury complaints occurred on over 40,000 acres of soybean, 1,000 acres of cotton, 700 acres of peaches, 400 acres of purple hull peas, 200 acres of peanuts, 32 acres of watermelon, 9 acres of cantaloupe, 6 acres of alfalfa, 2 acres of tomatoes, and on numerous homeowner's gardens, trees, and ornamental bushes. Some of the primary factors that contributed to the off-site movement of dicamba will be discussed, as well as the impacts that this situation has had and will continue to have on Missouri agriculture.

SCIENCE POLICY OUTLOOK FOR 2017. Lee Van Wychen*; National and Regional Weed Science Societies, Alexandria, VA (173)

REGULATORY CHENGES TO THE CONTINUED AVAILABILITY OF HERBICIDES AND THEIR UTILITY. Michael Barrett*; University of Kentucky, Lexington, KY (174)

It has become apparent to me over the past three years while serving at the WSSA liaison to the EPA Office of Pesticide Programs that there are growing regulatory chenges to the continued availability and utility of herbicides. The broad statue that governs the federal regulation of pesticides is the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This statue uses a cost-benefit analysis as part of the decision making process on pesticide registration. And, while EPA has always been very good at assessing risk, there is a renewed emphasis on benefit analysis. Reasons for this will be discussed. Other statues that come into play include the Clean Water Act and the Endangered Species Act (ESA). The last has raised a number of issues. A major difference between FIFRA and ESA is that ESA does not consider benefit, if there is a predicted risk to an endangered species then the pesticide use in question will likely not be owed. Of course, estimation of the risk and how conservative to be in establishing an acceptable risk level are points for contention. In addition, given the inherent phytotoxic nature of herbicides, it is very difficult for these compounds to not pose some risk to endangered plant species. There are a number of outcomes than have resulted from this problem including label instructions to insure there is no appreciable (or effective) off-site movement and tank-mixing prohibitions because of uncertainty concerning potential interactions (synergism) between tank-mix components. Adding to the uncertainty about the future of herbicides particularly, but rey pesticides, are requirements to reevaluate the registration of pesticides every 15 years (the first cycle of these reevaluations is just being made public), lawsuits chenging EPA decisions, inconsistency between efforts to protect pollinators and herbicide resistance management, other regulatory efforts to combat resistance evolution, and, amazingly, politics! Taken together, these will probably change what herbicides can be used, where they can be used, and how they can be used.

MILLENIALS IN AGRICULTURAL INDUSTRY. Brandy Tannahill*; Research Designed 4 Agriculture, Yuma, AZ (176)

Differing generational perspectives can easily prove to be the root of chenges for students entering the professional workplace, and for older employers to adopt younger employees to an existing work culture. For agriculture this is a very real issue, as many new fields of agriculture rely upon the competency and fluency of workers with technologies that previous generations (in modern times, the baby boomers) didn't have when establishing their companies. To move forward and make strides to feed the world in the most environmenty sustainable way, "Big Ag" companies, R&D firms, and even Crop Consultancies must work to adopt this new tech and in the process of this, bridge the generational and cultural gaps from millennials to baby boomers to reach ultimate success for the individual and their companies. Acting as your ag industry millennial emissary, Brandy Tannahill (Field Agronomist I – Research Designed for Agriculture - Yuma, AZ) has prepared a roundtable discussion and presentation on the integration of millennials to the workforce of agricultural industry, consulting, or R&D after college, and the benefits and struggles involved for employers of having millennials on staff. This talk will explore issues concerning generational and social perspectives, corporate culture contrasted with academia, utilization of technology for enhanced productivity, and employee retention.

EXPERIENCES AND IMPRESSIONS USING NEW TECHNOLOGY AND METHODS IN WEED EDUCATION AND OUTREACH. Andrew R. Kniss*; University of Wyoming, Laramie, WY (177)

CONTROLLING WEEDS IN STRAWBERRY THROUGHOUT THE YEAR. Bernard H. Zandstra*, Colin J. Phillippo; Michigan State University, East Lansing, MI (179)

Strawberry (*Fragaria x Ananassa* Duchesne.) is grown in Michigan as a perennial crop using the matted row production system. Transplants are set in the spring and fruit is harvested during May and June during the next two-three years. Good weed control is essential for maximum fruit production and maintenance of a productive stand for 3 years. Several preemergence and postemergence herbicides are registered for strawberry. However, annual, winter annual, biennial, and perennial weeds cause serious production problems. Strawberry weed control experiments are conducted in 2014, 2015, and 2016 at the Michigan State University Horticulture Farm on established strawberry on a Riddles sandy soil with 85% sand and 1.4% organic matter, to determine the most effective use of labeled herbicides and to test potential new herbicides for registration. A fall application was made in Fall 2014 and another experiment was established in Spring 2015. Both experiments were harvested in June 2015. Another spring experiment was conducted in 2016. The variety was Jewel, a common mid-season variety. On October 11, 2014, terbacil, sulfentrazone, acifluorfen, napropamide, pendimethalin, indaziflam, isoxaben, fomesefan, and flumioxazin were applied to dormant strawberry plants. The spring 2015 experiment was applied April 13, using the same treatments. Another experiment was established in spring 2016. In spring 2015, there was no difference in strawberry yield from any of the fall treatments. In the spring 2015 experiment, sulfentrazone at 0.28 kg ha^{-1} plus pendimethalin at 1.57 kg ha^{-1} caused some strawberry visual injury and yield reduction. Strawberry treated with indaziflam at 0.095 kg ha^{-1} had good yield and good weed control from both fall and spring applications. In the Spring 2016 experiment there was no statistical difference in yield from any treatment. Terbacil at 0.45 kg/ha had the highest yield because of excellent weed control. Bicyclopyrone at 0.05 kg/ha caused significant strawberry visual injury early in the spring, but yield was not reduced. Terbacil, napropamide, fomesafen, and flumioxazin applied in the fall 2014 provided good early control of white campion *(Silene latifolia* Poir.) in spring 2015. Fall-applied terbacil, indaziflam, and flumioxazin suppressed quackgrass (*Elytrigia repens* (L) Nevski). In spring 2015, only terbacil controlled quackgrass and horseweed (*Conyza canadensis* L). In spring 2016, *s*-metolachlor controlled hairy vetch (*Vicia villosa* Roth) and horseweed. Bicyclopyrone controlled hairy vetch. None of the treatments controlled weeds sufficiently. Registration of *s*-metolachlor, fomesafen, and isoxaben for strawberry should be approved in the future.

MANAGING WEEDS IN PEPPER AND TOMATO WITH NEW HERBICIDES. Colin J. Phillippo*, Bernard H. Zandstra; Michigan State University, East Lansing, MI (180)

Several residual-and post-emergence herbicides are registered for use in bell pepper, chile pepper, and tomato. Residual herbicides include clomazone, napropamide, s-metolachlor, imazosulfuron, pendimethalin, fomesafen, halosulfuron, and trifluralin. Post-emergence herbicide options include paraquat, rimsulfuron (tomato only), sethoxydim, halosulfuron, glyphosate, clethodim, and metribuzin (tomato only). However, several of these chemicals can cause severe crop injury, and consequently can only be used pre-transplant or as a directed post-emergence application. Some also come with rotational restrictions. Additional herbicide registrations would provide growers with an expanded toolkit for controlling problematic weeds in pepper and tomato crops. Weed control trials were conducted at the Horticulture Teaching and Research Center in East Lansing, MI to find additional herbicides for pepper and tomato. Residual herbicides tested were sulfentrazone + metribuzin, bicyclopyrone, sulfentrazone, and sulfentrazone + carfentrazone. Post-emergence herbicides included bicyclopyrone, pyridate, sulfentrazone + carfentrazone, and glufosinate. Sulfentrazone + metribuzin was not safe in pre-transplant applications on bell paper, but increased tomato yields. Sulfentrazone + metribuzin provided excellent control of common ragweed, redroot pigweed, wild radish, and yellow foxtail. Bicyclopyrone applied pre-transplant or post-emergence reduced yields in cherry pepper, banana pepper, bell pepper, and tomato. Bicyclopyrone provided good control of common ragweed and eastern black nightshade, and excellent control of redroot pigweed and yellow foxtail when used in combination with s-metolachlor. Pyridate applied post-emergence was safe on bell pepper, cherry pepper, and tomato. It provided good control of common ragweed, redroot pigweed, wild radish, and yellow foxtail. Pre-transplant applications of sulfentrazone were safe on bell pepper and tomato, and provided excellent control of redroot pigweed and yellow foxtail when used in combination with pendimethalin. Cherry and banana pepper plots sprayed with sulfentrazone + carfentrazone pre-transplant had similar yields to untreated plots, but yields were ly lower than plots treated with pendimethalin. Sulfentrazone + carfentrazone provided excellent control of eastern black nightshade, redroot pigweed, and wild radish. Glufosinate was safe on cherry pepper when applied both pre-transplant and post-directed at two rates, and provided excellent control of yellow foxtail, common lambsquarters, and redroot pigweed.

PROCESSING POTATO RESPONSES TO SUBLETHAL DOSES OF GLYPHOSATE AND DICAMBA. Harlene M. Hatterman-Valenti*, Andrew Robbinson, Collin Auwarter, Eric Brandvik; North Dakota State University, Fargo, ND (181)

Herbicide spray drift is the most common complaint in relation to pesticide use in North Dakota. With the development of glyphosate-resistant crops and the quick conversion to these cropping systems, glyphosate was often the herbicide suspected for off-target injury. However, dicamba-resistant soybean and the adoption of this technology to combat glyphosate-resistant weed problems, may cause even more drift injury to off-target horticultural crops. Dicamba is known to be volatile and can remain in spray equipment if not cleaned properly, which may injure off-target plants during spraying operations. A summary of two simulated drift studies using glyphosate, dicamba, and mixtures of both herbicides on potato (*Solanum tuberosum* L.) will be presented. Both studies used three sub-lethal doses at 10-fold increments of glyphosate and dicamba, along with the high, medium, and low doses of both herbicides mixed together. Herbicide doses were applied at tuber initiation. Visual injury observations were made 10 and 20 d after treatment (DAT), while yields and grades were collected at the end of the growing season. Visual injury symptoms for potato was greatest for doses that included dicamba, but was relatively low ≤ 13% at 10 DAT and increased two-fold or more by 20 DAT. Yield reduction compared to the untreated was greatest when doses included dicamba. Results suggest that drift injury potential to potato will be greater if a dicamba-resistant soybean crop is adjacent and upwind compared to a glyphosate-resistant crop.

WEED CONTROL STRATEGIES WITH EARLY KILLED RYE IN PROCESSING LEGUMES. James L. Moody*[1], Martin M. Williams[2], Nicholas E. Hausman[3]; [1]USDA/ARS, Champaign-Urbana, IL, [2]University of Illinois, Urbana, IL, [3]USDA/ARS, Urbana, IL (182)

Processing vegetable legumes have few herbicides for controlling weeds post-emergence in the crop, necessitating the use of additional tactics to reduce in-crop weed density and growth. Rye cover crop residues have proven effective at contributing to weed management in various crops, particularly if terminated before rye produces biomass levels associated with crop losses. The objective of this research was to determine the extent to which early-killed rye (EKR) and weed management influences weed emergence and growth, hand weeding time, and crop yield in edamame, lima bean, and snap bean. Field experiments were conducted at the Vegetable Crop Research Farm near Urbana, IL in 2015 and 2016. The preceding f of each year, a split-plot design was establish whereby main plots were either left fow (to become a stale seedbed, SSB) or planted to cereal rye which was killed the following spring in mid-April. Each vegetable legume was grown in a separate trial. Vegetable legumes were no-till planted mid-May, and subplots consisted of a 1) standard PRE and POST herbicide (standard), 2) standard treatment plus hand weeding (augmented), and 3) weedy. Rye biomass at burndown averaged 784 g m^{-2}. No interactions were observed between the main treatments for any response variable. Relative to SSB, EKR did not compromise edamame establishment, but crop population density was reduced 47% and 34% in lima bean and snap bean, respectively. The EKR treatment had no effect on weed density 39 d after planting; however, at-harvest weed biomass was reduced from 58% to 78% for edamame and snap bean, respectively. Relative to SSB, EKR decreased hand weeding time in edamame, but increased handweeding time in lima bean and snap bean. Based on machine-harvest yields, EKR did not affect edamame yield; however, EKR reduced yield of lima bean and snap bean 51% and 75%, respectively. Preliminary results show that EKR has low potential for use in lima bean and snap bean; however, EKR has high potential as an additional weed management tactic in edamame.

OVERVIEW TO NEW TECHNOLOGY. Travis Legleiter*; Purdue University, West Lafayette, IN (183)

APPLYING NEW MOLECULAR TECHNIQUES TO ADDRESS ISSUES RELATED TO HERBICIDE RESISTANCE, INVASIVE SPECIES AND THE GENETICS OF NON-MODEL ORGANISMS. Eric L. Patterson*; Colorado State University, Fort Collins, CO (184)

For molecular plant biologists, weeds offer a unique chenge. Unlike work done in model organisms, data about the genes, transcripts, and proteins in weeds are usuy unavailable and only obtainable through homology with a well-studied model system.   That is until relatively recently, when advances in sequencing, computer science and molecular techniques have opened the door for new inquiries into fundamental weed biology. In this talk I will discuss several new molecular techniques that can be utilized by researchers to address previously difficult to answer questions in weed biology. For instance, PCR-RFLPs for SNP detection can now be replaced with KASP assays, qPCR and copy number assays can now be performed with ddPCR, microarrays replaced with RNA-SEQ, microsatellite based population genetics with Genotyping by sequencing (GBS), and linkage mapping with Genome Wide Association Studies (GWAS) to find candidate genes, just to name a few. In this talk I will discuss how the Colorado State University weed lab is employing these modern molecular techniques to answer questions about herbicide resistance, weed population dynamics, invasive species biology, and general questions of weed biology.

TECHNOLOGY AND INTELLEGENT WEED AND FARM MANAGEMENT. Joel Wipperfurth*; Winfield, St. Paul, MN (185)

What if a new way of weed control was being developed right now in a parel universe? Would you wonder what new mode of action it was? Or maybe what weeds it can control, and better yet what new exciting tank mixes it can create. Maybe you would wonder who the scientist is or what their laboratory looks like they created it in. The next new way to kill a weed may very well be a class ced Digital weed control. Data scientist, programmers and developers from venture backed startups to basic manufacturers have their eye on a new multibillion-dollar market aimed at digity killing weeds. Sub categories of digital weed control will be working together with cloud based information delivering it to the palm of your hand on your mobile device. Improvement in spatial temporal and spectrum analysis are happening in earth observatory, manned and unmanned image capture. Big data is being exposed to machine learning and artificial intelligence systems advancing forecasting, predictability and analytic capability. Advances in technology verticals will surely make impacts individual contributions, but the convergence of imaging, sensors, algorithms, cloud computing, 5GLTE, autonomous swarms of bots, and weed science will have the largest impact by working together as a system.

UAS DATA ANALYSIS AND OUTCOMES: BEST PRACTICE AND USE CASES. Orlando Saez*; Aker Company, Winnebago, MN (186)

MAINTAINING SPRAY DROPLET UNIFORMITY WITH NEW SPRAY TECHNOLOGIES. Wayne Steward[1], Bruce Bode*[2]; [1]Pentair Hypro, New Brighton, MN, [2]Pentair Hypro, Omaha, NE (187)

NEW SPRAY NOZZLE DEVELOPMENTS FROM TEE JET TECHNOLOGIES. Kevin Humke*; TeeJet Technologies, Urbandale, IA (188)

MAXIMIZING COVERAGE WITH LOW DRIFT NOZZLES. Will Smart*; Greenleaf Technologies, Covington, LA (189)

GREENLEAF INCORPORATED TECHNOLOGY PRESENTATION. Al Harmon*; Greenleaf Inc., Fontanet, IN (190)

WILLMAR FABRICATION TECHNOLOGY PRESENTATION. Steve Claussen*; Willmar Fabrication, LLC, Willmar, MN (191)

BENEFITS OF PWM SPRAY SYSTEMS FOR PRODUCTION AGRICULTURE AND RESEARCH. Brian Finstrom*; CapstanAG, Topeka, KS (192)

ENVIRONMENTAL FACTORS MODERATE THE GLYPHOSATE-INDUCED ANTAGONISM OF TANK-MIX HERBICIDES ON RAPID NECROSIS GLYPHOSATE-RESISTANT GIANT RAGWEED. Nick T. Harre*[1], Steve Weller[2], William G. Johnson[3], Bryan Young[2]; [1]Purdue University, West Lafayette, IL, [2]Purdue University, West Lafayette, IN, [3]Purdue, West Lafayette, IN (193)

A central tenet in herbicide physiology is that a plant must be actively growing for a herbicide to fully elicit an effect. Thus, it is genery held that environmental conditions conducive to plant growth increase herbicide efficacy. A common management tool to control rapid necrosis, glyphosate-resistant (RN) giant ragweed is to apply an additional selective herbicide in tank-mixture with glyphosate. However, past research has shown the propensity of the glyphosate-induced RN response to antagonize several phloem-mobile herbicides and anecdotal evidence suggests the onset of the RN response to be regulated by air temperature. Therefore, this research investigated how this, and other environmental factors influence the interactions between glyphosate and selective herbicide tank-mixtures.,Greenhouse and growth chamber experiments were performed aimed to address the transient (6 d) effect of air temperature (10 and 30 C), soil moisture (1/3 and full pot capacity), and light intensity (1/2 and full light) on RN giant ragweed treated with glyphosate alone, or in combination with atrazine, cloransulam, dicamba, lactofen, and topramezone. Accumulation of H_2O_2, indicative of the RN response, was measured at 0.5 h intervals following glyphosate treatment and revealed air temperature to have the greatest effect on the induction of the RN response as plants at 30 C had 133% more H_2O_2 compared to 10 C, at 2.5 h after treatment. Likewise, H_2O_2 accumulation was 50% greater at full pot capacity compared to 1/3 pot capacity and 18% greater in full light compared to 1/2 light. Antagonism by glyphosate on cloransulam, dicamba, and topramezone was present across tested environmental conditions and on atrazine under 30 C conditions. However, the magnitude of glyphosate-induced antagonism was greater on cloransulam, dicamba, and topramezone at 30 C vs 10 C, and on cloransulam and topramezone at full pot capacity vs 1/3 pot capacity. These results indicate the onset of the RN response in giant ragweed occurs sooner under environmental conditions favorable to plant growth and consequently, increases the likelihood of antagonism by glyphosate on several phloem-mobile herbicide tank-mixtures.

IMPLICATIONS FOR GLYPHOSATE RESISTANT PALMER AMARANTH AND KOCHIA WHICH NOW COMINGLE IN COLORADO. Philip Westra*[1], Todd A. Gaines[2], Franck Dayan[2]; [1]Colorado State University, Ft. Collins, CO, [2]Colorado State University, Fort Collins, CO (194)

Glyphosate-resistant kochia has increased in prevalence across the North American Great Plains, threatening hard won advances in reduced-tillage crop production systems. Glyphosate-resistant Palmer amaranth has been perceived as primarily a problem of the southern US in cotton, soybean, and corn production areas. Kochia is extremely cold tolerant and one of the first species to initiate germination and growth in the spring. Palmer amaranth exhibits a very rapid growth rate once established under warm conditions and both species are prolific seed producers. Kochia is a tumbleweed while Palmer amaranth is a dioecious and remains fixed in place until f death. Both weeds exhibit gene amplification of EPSPS as an effective mechanism of glyphosate resistance, with Palmer amaranth typicy exhibiting much higher EPSPS gene copy numbers than kochia. Where these plants occur, normal glyphosate rates are ineffective for control. In 2016, a site in Colorado and a site in southern Nebraska were documented having both glyphosate-resistant species present in sugarbeet fields. This is especiy problematic as there are few safe, effective alternative herbicides for control of these weeds in sugarbeets. Georeferenced field sampling in the f of 2016 will show the extent of infestations of these two species. This recent discovery forces a thorough evaluation of what future implications will be for effective control of these two species.

FEASIBILITY OF AMS REPLACEMENT ADJUVANTS IN THE NEW GLYPHOSATE PLUS PHENOXY HERBICIDE SYSTEMS. Scott Parrish*[1], Jim Daniel[2], Philip Westra[3]; [1]AGRASYST, Logan, UT, [2]AGRASYST, Hudson, CO, [3]Colorado State University, Ft. Collins, CO (195)

AQ 2110, a water conditioning spray adjuvant, has shown better efficacy improvements for glyphosate plus a phenoxy herbicide application as compared to the traditional additives of ammonium sulfate (AMS) plus a non-Ionic surfactant (NIS). AQ 2110 contains both Drift Reduction Technology (DRT) and Volatility Reduction Technology (VRT). Glyphosate plus phenoxy tank mixes using traditional AMS + NIS spray adjuvants have demonstrated increases in off-target movement of the phenoxy herbicide component. Two mechanisms for off-target movement, mechanical drift and vapor drift, were investigated using AQ 2110 compared with AMS + NIS as spray adjuvants in glyphosate plus phenoxy tank-mixtures. A standard, fully-loaded glyphosate + AMS reduced the volume median diameter (VMD) of spray particles by about 10% as compared to water only. The fully loaded glyphosate formulation applied with 0.5% v v^{-1} AQ 2110 showed an increase in the VMD of spray particles by 5% over water only. In field studies with glyphosate + dicamba tank mixes, AQ 2110 at the 0.5% v v^{-1} use rate reduced off-target movement by an average of 45% in 2015 and 33% in 2016 as compared to the AMS + NIS treatments. Off target movement via volatility in these same field studies were reduced by AQ 2110 an average of 84% in 2015 and 96% in 2016 as compared to AMS + NIS. Greenhouse experiments showed volatility injury ratings increased an averaged of 27% when the DGA salt of dicamba was applied with AMS + NIS. Acidic AMS Replacement (AAR) adjuvants increased dicamba volatility injury rating by an average of 31%; however, AQ 2110 reduced the dicamba volatility injury rating by an average of 36%.

MOLECULAR BASIS OF HERBICIDE RESISTANCE IN A MULTIPLE-RESISTANT WATERHEMP (*AMARANTHUS RUDIS)* POPULATION FROM MISSOURI. Lovreet S. Shergill*[1], Mandy D. Bish[2], Kevin W. Bradley[1]; [1]University of Missouri, Columbia, MO, [2]University of Missouri, 65211, MO (196)

Waterhemp is currently the most problematic annual weed species in crop production systems in the Midwest. Waterhemp populations have evolved resistance to one or more of six groups of herbicides: the synthetic auxins, the 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS), protoporphyrinogen oxidase (PPO), acetolactate synthase (ALS), photosystem II (PSII), and 4-hydroxyphenyl-pyruvate-dioxygenase (HPPD)-inhibiting herbicides. In 2014, a grower in north central Missouri reported increasing difficulty in managing a waterhemp population with numerous herbicides, including 2,4-D. Subsequent dose-response studies were conducted and confirmed five-way resistance to the synthetic auxins, EPSPS-, PPO-, ALS-, and PSII- inhibitors. Following the confirmation of resistance, the molecular basis for resistance was studied. DNA sequencing confirmed the presence of a well-characterized point mutation in the gene that encodes the ALS enzyme and results in a Trp-574-Leu substitution, which is associated with resistance to ALS-inhibitors. Sequence analysis of the *PP2XL* gene confirmed the codon deletion mutation that corresponds to ΔG210 and is known to confer resistance to PPO-inhibitors. The *EPSPS* gene was sequenced and lacked the point mutation corresponding to the Pro-106-Ser substitution; one mechanism known to confer glyphosate resistance. Further molecular investigations are underway to characterize the mechanism of resistance to synthetic auxins, PSII- and EPSPS-inhibiting herbicides.

EFFECTS OF PGRS AND MOWING MANAGEMENT ON ROADSIDE T FESCUE. Joe Omielan*, Michael Barrett; University of Kentucky, Lexington, KY (197)

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 but reduced mowing schedules are being used to cut costs. To maintain highway safety, the zone next to the roadway (clear zone) might be mowed three times per season while the remaining right of way (selective zone) is only mowed once per season. Plant Growth Regulators (PGRs) are potential tools to reduce turf growth and aid in keeping our roadways safe for travelers. This trial was established to examine the interaction between different PGRs and mowing management regimes. A trial was established in 2016 at Spindletop Research Farm in Lexington KY arranged as a split-plot design with three mowing regimes, 16 PGR treatments, and three replications. Main plots were nine m wide and the mowing regimes were three times per season, once at the end of the season, and unmowed. Sub plots were three m by nine m with running unsprayed checks between each of the plots. The treatments were five PGRs applied one to two wk after each of the three mowings plus control. They included products and tank-mixtures using one or more of the following active ingredients: aminocyclopyrachlor, aminopyralid, chlorsulfuron, imazapic, mefluidide, metsulfuron methyl, prohexadione calcium, and 2,4-D. applications were at 234 l ha^{-1} and included a non-ionic surfactant at 0.25% v v^{-1}. Application dates were 5/24/2016, 7/19/2016, and 10/6/2016. 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. Canopy heights were measured. Data were analyzed using ARM software and treatment means were compared using Fisher's LSD at $p = 0.05$.

MODELING THE SPREAD OF PALMER AMARANTH ACROSS IOWA AND THE MIDWEST CORNBELT STATES. Tre B. Loge*, Park Mikels, Leslie Decker, Andrea Van Wyk, Maggie E. Long; Simpson College, Indianola, IA (198)

The Palmer Amaranth Think Tank, a group of undergraduate students located at Simpson College in Indianola, Iowa, is focused on researching the spread of Palmer amaranth across the Midwest Corn Belt. In order to demonstrate how serious of a problem Palmer amaranth may be in the future, we used an agent-based simulation software ced NetLogo. Starting in the counties confirmed to have Palmer amaranth, we showed how the weed spreads across the Corn Belt through machinery, wind, and places where manure is used, (such as hog confinements). Each land unit has a field type of corn, soybean, CRP, or none. We will also talk about Palmer amaranth seed discovered in CRP mixes. Lastly, we will discuss using the Briar Score to verify our model.

IMPACT OF HERBICIDES ON SALTCEDAR AND ASSOCIATED VEGETATION. Walter H. Fick*; Kansas State University, Manhattan, KS (199)

Saltcedar (*Tamarix ramosissima*) is an invasive woody species found along streams, rivers, reservoirs, and wetlands occurring from Kansas to North Dakota in the northcentral region of the U.S. It is also found in the southwest and parts of southeastern U.S. The species decreases water quantity and quality, cycles salt, and decreases forage production and species richness. Saltcedar resprouts prolificy following cutting, fire, or grazing. The objective of the current study was to compare the efficacy of imazapyr, imazapic, and triclopyr for saltcedar control in southwest Kansas and to assess the impact of these herbicides on associated vegetation. The study site was located on the Cimarron National Grasslands in Morton County, Kansas. Herbicides included foliar applications of 1% imazapyr + 1% methylated seed oil and 1% imazapic + 1% methylated seed oil. The treatments were compared to basal treatment with 10% triclopyr in diesel. Treatments were applied on August 29, 2014 and September 17, 2015. treatments, including an untreated check, were applied in a completely randomized design with four replications. Each plot was about 7.6 x 7.6 m in size, with foliar treatments applied at 432 L ha^{-1}. Mortality and vegetative cover were determined for treatments about 1 year after treatment. Saltcedar control was similar between years with imazapyr and imazapic providing 93% and 85% control, respectively. A basal treatment of 10% triclopyr in diesel provided only 43% control. There was a tendency for perennial grasses to decrease and forbs to increase on treatments, including the untreated checks. The greatest change in herbaceous vegetation occurred in the imazapyr treated plots as perennial grasses decreased 93% and forbs increased 68%. Above normal precipitation in 2015 and 2016 likely stimulated broadleaf plant populations. Kochia (*Kochia scoparia*) increased dramaticy as the grasses and canopy cover of saltcedar decreased. Composite dropseed (*Sporobolus compositus*) and western wheatgrass (*Pascopyrum smithii*) disappeared from plots treated with imazapyr in 2014 and 2015. Alkali sacaton (*Sporobolus airoides*) was eliminated from imazapyr treatments in 2014 with cover reduced 93% in 2015 treated plots. Perennial grasses persisted better in plots treated with imazapic. Previous studies have recommended imazapyr for saltcedar control. Imazapic provides an alternative herbicide for saltcedar control with less damage to associated herbaceous vegetation.

PLANNED COMMERCIAL FORMULATIONS CONTAINING VAPORGRIP TECHNOLOGY FOR USE IN THE ROUNDUP READY 2 XTEND CROP SYSTEM. Alison MacInnes*; Monsanto Company, St Louis, MO (200)

Monsanto Company has developed formulations containing dicamba for use in the Roundup Ready® Xtend™ Crop System. XtendiMax™ with VaporGrip™ technology is a dicamba standalone formulation based on the diglycolamine (DGA) dicamba salt. Roundup Xtend™ with VaporGrip™ technology is a pre-mix formulation containing DGA dicamba and monoethanolamine (EA) glyphosate delivering a 2 to 1 ratio of glyphosate to dicamba. Both formulations contain proprietary VaporGrip™ technology that reduces the potential of dicamba volatility compared to current commercial dicamba formulations. XtendiMax™ with VaporGrip™ technology and Roundup Xtend™ with VaporGrip™ technology show commerciy acceptable physical/ chemical properties consistent with Roundup® agricultural herbicide formulations and are pending regulatory approval for in-crop use.

DUPONT HERBICIDE PROGRAMS FOR MARESTAIL CONTROL IN DICAMBA-TOLERANT SOYBEAN. Kelly A. Backscheider*[1], David H. Johnson[2], Kevin L. Hahn[3], Bruce V. Steward[4], Jeffery T. Krumm[5], Victoria A. Kleczewski[6], Michael D. Meyer[2]; [1]DuPont Crop Protection, Shelbyville, IN, [2]DuPont Crop Protection, Johnston, IA, [3]DuPont Crop Protection, Bloomington, IL, [4]DuPont Crop Protection, Overland Park, KS, [5]DuPont Crop Protection, Hastings, NE, [6]DuPont Crop Protection, Middletown, DE (201)

Glyphosate-resistant weeds continue to present control chenges to growers, and dicamba-tolerant soybeans will provide a new tool for in-crop weed control in soybeans. DuPont is working to develop multiple-mode-of-action, residual weed control programs that include dicamba. In this presentation we will show that various combinations of DuPont soybean herbicides provide growers with excellent marestail (Conyza canadensis) control in dicamba-tolerant soybeans.

DUPONT HERBICIDE PROGRAMS FOR WATERHEMP AND PALMER AMARANTH CONTROL IN DICAMBA-TOLERANT SOYBEANS. David Johnson*[1], Jeffery T. Krumm[2], Michael D. Meyer[3], Kelly A. Backscheider[4], Kevin L. Hahn[5], Richard Edmund[6], Bruce V. Steward[7], Robert Rupp[8], Dan Smith[9], Eric Castner[10], Victoria A. Kleczewski[11]; [1]DuPont Crop Protection, Des Moines, IA, [2]DuPont Crop Protection, Hastings, NE, [3]DuPont Crop Protection, Johnston, IA, [4]DuPont Crop Protection, Shelbyville, IN, [5]DuPont Crop Protection, Bloomington, IL, [6]DuPont Crop Protection, Little Rock, AR, [7]DuPont Crop Protection, Overland Park, KS, [8]DuPont Crop Protection, Edmund, OK, [9]DuPont Crop Protection, Madison, MS, [10]DuPont Crop Protection, Weatherford, TX, [11]DuPont Crop Protection, Middletown, DE (202)

Glyphosate-resistant weeds continue to present control chenges to growers, and dicamba-tolerant soybeans will provide a new tool for in-crop weed control in soybeans. DuPont is working to develop multiple-mode-of-action, residual weed control programs that include dicamba. In this presentation we will show that various combinations of DuPont soybean herbicides provide growers with excellent common waterhemp (Amaranthus rudis) and Palmer amaranth (Amaranthus palmeri) control in dicamba-tolerant soybeans.

2,4-D CHOLINE AND GLUFOSINATE WEED CONTROL OPTIONS IN ENLIST SOYBEAN. Mike Moechnig*[1], David M. Simpson[2], Dave Ruen[3], Kristin K. Rosenbaum[4], Kevin Johnson[5], Laura A. Campbell[6], Eric Scherder[7], Sunil S. Tewari[8]; [1]Dow AgroSciences, Brookings, SD, [2]Dow AgroSciences, Indianapolis, IN, [3]Dow AgroSciences, Lanesboro, MN, [4]Dow AgroSciences, Crete, NE, [5]Dow AgroSciences, Danville, IL, [6]Dow AgroSciences, Carbondale, IL, [7]Dow AgroSciences, Huxley, IA, [8]Dow AgroSciences, West Lafayette, IN (203)

A new formulation of 2,4-D choline, GF-3335, developed by Dow AgroSciences contains Colex-D® technology that provides low volatility and drift reduction characteristics similar to Enlist Duo® herbicide (2,4-D choline + glyphosate). This formulation has been designed for compatible tank-mixing with either glyphosate or glufosinate products. Field trials were conducted in 2016 to evaluate Enlist™ soybean tolerance and weed control associated with single applications of GF-3335 mixed with different branded formulations of glyphosate products and glufosinate products. Weed control trials were conducted in seven states on nine sites containing glyphosate-resistant weed biotypes, including waterhemp (*Amaranthus rudis*), Palmer amaranth (*Amaranthus palmeri*), common ragweed (*Ambrosia artemisiifolia*), and horseweed (*Conyza canadensis*). Results demonstrated that weed control was similar among most glyphosate and glufosinate formulations when added with GF-3335 and that efficacy was genery similar between glyphosate and glufosinate mixes with GF-3335 for most weed species even though they were glyphosate-resistant biotypes. Additional trials were conducted in four states on four sites with no weed densities to evaluate Enlist soybean growth-response and yield to the same treatments. Soybean growth and yield responses were minimal and similar among applications of GF-3335 plus glyphosate or glufosinate formulations. In summary, the new 2,4-D choline with Colex-D formulation, GF-3335, may be tank-mixed with several glyphosate and glufosinate formulations to achieve excellent control of several chenging glyphosate-resistant weed biotypes in Enlist soybeans while maintaining excellent crop tolerance, growth, and yields.

WHAT IS A TEMPERATURE INVERSION? IDENTIFYING, CHARACTERIZING, AND ANALYZING THE FREQUENCY OF SURFACE TEMPERATURE INVERSIONS IN MISSOURI. Mandy D. Bish*[1], Kevin W. Bradley[2]; [1]University of Missouri, 65211, MO, [2]University of Missouri, Columbia, MO (204)

Temperature inversions occur when air nearest the earth's surface becomes cooler than the air above it. The resulting stable air mass can promote the suspension of herbicide particles in the air instead of the droplets reaching the target plants. Historicy, most studies characterizing temperature inversions have focused on atmosphere elevations that are much higher than applications made from a ground sprayer. The focus of this ongoing research is to identify and monitor the frequency, duration, and intensity of surface temperature inversions at heights relevant to ground applications and within different regions of Missouri. In 2015, weather stations at three geographicy-distinct locations within Missouri were fitted with air temperature sensors at 46, 168, and 305 cm above the soil surface. Temperatures were recorded every three seconds, and those temperatures were averaged to generate a 5-minute temperature reading at each height. The 5-minute temperatures were compared to identify inversions in which air temperature at 46 cm was coolest and air temperature at 305 cm was warmest. Based on air temperature alone, three weather stations registered inversions in each month of the growing season in 2015 and 2016; they were typicy longer than 10 hours. Preliminary analysis across locations during the 2016 growing season indicates that inversions most frequently formed between 5:00 and 7:00 p.m. Inversions are also associated with calm winds of less than 1.34 kmh^{-1}. Missouri weather stations are equipped with anemometers at 305 cm. The five-minute wind speed averages were retrieved from a University of Missouri Weather Station located in southeast Missouri from March to July of 2016. The wind speeds at 168 cm, or the middle height of the monitored air-temperature inversions, were extrapolated using the log-wind profile equation. Preliminary analysis indicated that air temperature inversions correlated with low wind speeds greater than 90% of the time in May, June, and July, and greater than 75% of the time in March and April. Analysis of wind speeds combined with air temperature inversions for each location over 2015 and 2016 is ongoing. Dew is another indicator of an inversion; as air temperatures near the earth's surface cool to the dew point temperature, dew forms. To determine the number of inversions that may have been associated with dew formation at the Hayward Lee Weather Station in 2016, the 5-minute air and dew point temperatures from the 46 cm sensors were compared. Over 80% of the inversions that occurred in June and July had air temperatures that reached dew point temperatures. This typicy occurred in the morning hours well after the onset of the inversion. Analysis of air and dew point temperatures for three locations in both years continues. This research will be utilized to equip Missouri herbicide applicators with more detailed information regarding the frequency, duration, and indicators of surface temperature inversions.

EFFECT OF S-METOLACHLOR AT VARIOUS APPLICATION RATES ON SUGARBEET CROP SAFETY AS INFLUENCED BY DIFFERENT ENVIRONMENTAL CONDITIONS. Andrew B. Lueck*, Thomas J. Peters; North Dakota State University, Fargo, ND (206)

S-metolachlor is one of two herbicides applied pre-emerge in sugarbeet, but concerns about crop safety prevent product labelling that does not force the farmer to assume liability. The working hypothesis is S-metolachlor applied pre-emerge at various rates between 0 and 1,076 grams active ingredient per hectare (g ai ha^{-1}) is safe for sugarbeet (*Beta vulgaris L.*) across different soil textures and environments. A single, susceptible sugarbeet seed variety was selected from preliminary screening. Experiment was a six replication, completely-randomized design, split-plot factorial arrangement with temperature as the whole-plot and sub-plot level treatments consisting of S-metolachlor rate, soil-type, and soil field capacity. Experiment evaluated the interaction of temperature, field capacity, and soil type with five S-metolachlor rates 0, 269, 538, 807, and 1,076 g a.i. ha^{-1} applied pre-emerge on sugarbeet. Treatments were first placed into a 7 C growth chamber for seven d. Experimental units were then split into two other growth chambers set at 14 C and 21 C based on each treatments whole plot designation. Four hundred grams of soil was weighed for each pot and a standardized procedure was developed for an accurate seeding depth of 2.5 cm. Five sugarbeet seeds were planted in each pot. Field capacities of 75% and 100% were calculated for each soil type and water was added accordingly to the pots prior to herbicide application. S-metolachlor was applied at 100 L ha^{-1} through 8001XR nozzle at 4.82 km h^{-1} and 276 kilopascals (kPa). Fresh weight per pot, average plant fresh weight, average d to emergence, and total emergence observations of the sugarbeets were measured. Results indicated soil type, field capacity, and S-metolachlor rate affected both fresh weight per pot and average plant fresh weight. Soil type, temperature, field capacity, and the interaction of the environment as a whole, (soil type x temperature x field capacity), affected the average d to emergence and total emergence, but there was no effect from herbicide rate. S-metolachlor rate applied pre-emerge affected sugarbeet vigor, but did not directly affect sugarbeet emergence. In conclusion, sugarbeet emergence is most dependent on environmental factors and not dependent on S-metolachlor application rates.

WEED CONTROL WITH GLUFOSINATE IN SOYBEAN IN A CROPPING SEQUENCE THAT INCLUDES SUGARBEET. Thomas J. Peters and Andrew B. Lueck, Assistant Professor and Research Specialist, Plant Sciences Department, North Dakota State University and the University of Minnesota, Fargo, ND 58105. (207)

Glufosinate has been an effective means of broad-spectrum grass and broadleaf control in soybean since regulatory approval in 2008. Glufosinate is applied post-emergence at 0.59 to 0.73 kg a.i./ha between soybean emergence and pre bloom when weeds are up to eight cm. A repeat glufosinate application can be used up to 0.73 kg a.i./ha. Glufosinate is applied with ammonium sulfate at 3.36 kg/ha in 140 L/ha water or greater through nozzles and pressure that produce a medium sized droplet. Glufosinate applied over LibertyLink crops offers herbicide flexibility since it is a unique site-of-action (SOA 10) and controls resistant weeds including kochia, common ragweed, and waterhemp. Sugarbeet growers in Minnesota and North Dakota extensively use glyphosate for weed control in sugarbeet. The 2014 weed control and production practices survey indicated on average growers used 2.3 applications of glyphosate per season for weed control. The survey indicated 93% of herbicide applications for weed control in sugarbeet were glyphosate. Sugarbeet is planted in a crop sequence that changes depending on location in Minnesota and North Dakota. A typical four year cropping sequence might be corn, soybean, spring wheat, and sugarbeet in the northern region, and corn, soybean, corn, and sugarbeet in the southern region. Thus, a glyphosate tolerant crop may be planted in the field every year in the cropping sequence. It is vital that glyphosate remain a viable weed control option in sugarbeet since growers have a limited number of herbicide options. There has been tremendous focus to reintroduce soil residual herbicides into the sugarbeet cropping sequence and use tank-mixtures to introduce multiple effective herbicides into the weeds management system. Corn, soybean, and sugarbeet experiments were conducted in adjacent blocks at three locations in 2014, 2015, and 2016 to simulate the grower cropping sequence. Individual experiment was a trait/crop combination and herbicide treatments selected to control the most important weed challenge at each location. While experiments followed the cropping sequence, there was no attempt to map herbicide history or to make inferences about herbicide use pattern. Rather, the goal simply was to create awareness of a weed management strategy across crops for control of difficult to control weeds including implementing herbicide diversity. Fields were selected that featured one primary and one secondary weed problem. In cases, the primary or secondary weed problem was a glyphosate resistant weed, either waterhemp or kochia. Lambsquarters was the most common secondary weed. Glufosinate and LibertyLink soybean were an important component of the weed control strategy. In addition to introducing a unique SOA, glufosinate in a systems approach is very effective for control of waterhemp, a common weed in sugarbeet production. Glufosinate in a system controlled 100%, 99%, and 92% waterhemp in 2014, 2015, and 2016, respectively, averaged across Herman and Moorhead, MN locations. Treatments that did not contain glufosinsate controlled 80%, 62%, and 91% waterhemp. Glufosinate is less active on lambsquarters. However, control was excellent in a systems approach when precipitation activated soil-applied herbicides. Glufosinate in a system controlled 99% and 95% lambsquarters in 2014 and 2015, respectively, across Barney, ND and Herman and Moorhead, MN, but controlled only 69% lambsquarters in 2016, when precipitation to activate soil-applied herbicides was not timely. Glufosinate can be combined with effective herbicides for weed spectrum when preemergence herbicides are combined with post-emergence herbicides. However, a post-emergence only system is more challenging, especially since tank-mixing glufosinate to broaden broadleaf control spectrum tends to increase soybean injury. Site of Action diversity using the glufosinate-based system in soybean contributed to a Shannon Diversity Index value of 1.98 as compared to 1.12 for the traditional glyphosate-based system across the cropping sequence.

MANAGEMENT OF VOLUNTEER WINTER WHEAT IN SUMMER SEEDED ALFALFA. Chris Bloomingdale*[1], Richard Proost[1], Mike Bweg[2], Mark Renz[1]; [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin - Extension, Sheboygan, WI (208)

Late-summer alfalfa seedings are common after wheat harvest in Wisconsin. However, control of volunteer wheat in no-till operations continue to chenge producers. Previous research has found winter wheat can reduce alfalfa establishment if not controlled. Interest exists in using Roundup Ready alfalfa and glyphosate to control volunteer wheat, but limited information is available on its effectiveness on winter wheat control, ability to prevent establishment failure, and enhance alfalfa yield the following spring. To address these questions, a study was initiated in 2015 at three locations across Wisconsin to compare the efficacy of glyphosate, imazamox, and sethoxydim in controlling volunteer wheat in alfalfa. Research sites were located in central (Arlington), eastern (Sheboygan), and southwestern (Lancaster) parts of the state. Roundup Ready alfalfa was seeded into fields where winter wheat was harvested earlier that summer. Glyphosate at 0.86 kg ae ha^{-1} (Roundup WeatherMAX) + ammonium sulfate (AMS) at 0.02 kg l^{-1}, sethoxydim at 0.31 kg ae ha^{-1} (Poast Plus) + AMS at 0.02 kg L^{-1} + crop oil concentrate at 1.7% v/v, and imazamox at 0.03 kg ae ha^{-1} (Raptor) + AMS at 0.02 kg l^{-1} + methylated seed oil at 1% v v^{-1} were applied at one of two timings. The early application was made when wheat was 10 to 15 cm tall and alfalfa was at the two-three trifoliate leaf stage; the late application was made 12-20 d later, when wheat was 15 to 30 cm tall. Herbicide efficacy on volunteer wheat 28 DAT, spring alfalfa stand counts the following April, and forage yields from the first harvest in May were compared across treatments, averaging results over three locations. Volunteer wheat control 28 DAT was different among herbicides ($p<0.001$) and between timing of application ($p=0.03$). Glyphosate provided 100% control, while sethoxydim had 12% and imazamox 35% less control than glyphosate. While the early timing did provide better control, it was only a 10% improvement compared to the late timing. Alfalfa stand establishment was also impacted by herbicide treatments ($p<0.001$) and timing of application ($p<0.001$). Glyphosate and sethoxydim treatments had stem densities above 750 stems m^{-2}, with imazamox treatments with reduced stem density (540 stems m^{-2}) but still twice as high as non-treated controls (280 stems m^{-2}). Timing of application also improved establishment with a 15% increase in stem density when applied early. Forage yield was highest in untreated plots as volunteer wheat was not controlled, but alfalfa yields were different among herbicide treatments ($p=0.001$) and between the two timings of application ($p<0.001$). As with volunteer wheat control and stand establishment, glyphosate provided the highest yield of alfalfa, with reductions in yield of 19 and 38% from sethoxydim and imazamox treatments respectively. Earlier applications also improved alfalfa yield compared to late timings by 22%. While current results suggest that use of glyphosate would provide more benefit compared to other treatments, the forage quality of the volunteer wheat needs to be considered. If harvested at the correct stage of development, having volunteer wheat present in alfalfa may increase milk production. Future analyses will focus on determining an acceptable level of volunteer wheat that minimizes stand loss and maximizes milk production.

VISUALIZATION OF DEPOSITION AND DRIFT OF AERIY APPLIED SPRAY MIXTURES. Raymond L. Pigati*[1], Eric P. Spandl[1], Gregory K. Dahl[2], Anothony Goede[1], JoAnna A. Gillilan[3], Ryan J. Edwards[2], Joe V. Gednalske[2]; [1]Winfield United, Shoreview, MN, [2]Winfield United, River Fs, WI, [3]Winfield United, Springfield, TN (209)

Visually capturing spray patterns from a fixed wing aircraft while simultaneously collecting deposition from spray mixtures is a novel way to pair qualitative visual observations with quantitative deposition data. A spray drift and deposition research and demonstration event was conducted near Chilton, WI to evaluate the correlation between the two. The research and demonstration event was conducted at the Flying Feathers airport using an Air Tractor 502 A airplane. It was flown by Dean Heimmerman. Treatments were applied in 18.7 or 46.8 l ha^{-1} water at 241 kph^{-1} with a boom height of approximately three m above the ground. Collectors were placed perpendicular to the flight path, spaced at three m intervals. Visual recordings were made with a high-speed digital camera which was fixed on a boom lift approximately 6 m above the ground. Treatments were replicated four times, cards were collected between each pass. Tank-mixtures included rhodamine dye at 250 milliliters per 100 liters. Various commercial and experimental drift reducing adjuvants were included in the tank-mixtures and compared to each other for visual and quantitative drift and deposition performance. The application with water alone moved downwind more when compared to treatments with adjuvants, as seen in the video and the collection cards. Data from visual observations and collection cards showed that visual evaluations and collecting deposition cards correlated when evaluating treatments for drift and deposition.

SPRAY DROPLET SIZE AND CARRIER VOLUME EFFECT ON DICAMBA AND GLUFOSINATE EFFICACY. Thomas R. Butts*[1], Chase A. Samples[2], Darrin M. Dodds[2], Dan B. Reynolds[2], Jason W. Adams[3], Richard K. Zollinger[3], Kirk A. Howatt[3], Greg R. Kruger[1]; [1]University of Nebraska-Lincoln, North Platte, NE, [2]Mississippi State University, Mississippi State, MS, [3]North Dakota State University, Fargo, ND (210)

Pesticide input costs have increased in Nebraska by nearly one-half billion US dollars over the past decade. More precise and efficient pesticide applications are necessary to meet regulatory demands and reduce input costs for farmers. Particular interest has been placed on increasing droplet size to minimize the drift potential of pesticide applications. The objective of our research was to evaluate the effect of spray droplet size and carrier volume on dicamba and glufosinate efficacy. A field trial was conducted at three sites across three states (Mississippi, Nebraska, and North Dakota) in a fow environment. Data presented are from the Nebraska location only. The trial was a randomized complete block design and treatments were arranged in a 2x6 factorial which consisted of two carrier volumes (47 and 187 L ha^{-1}) and six droplet sizes (150, 300, 450, 600, 750, and 900 µm) determined from the $D_{v0.5}$ of the measured spray solution. The $D_{v0.5}$ parameter represents the droplet size such that 50% of the spray volume is contained in droplets of equal or lesser values. Nozzle type, orifice size, and application pressure required to create each droplet size treatment were determined through droplet size measurements made using a Sympatec HELOS-VARIO/KR laser diffraction system. One nontreated control was used for comparisons which provided a total of 25 treatments. treatments were applied using a PinPoint® pulse-width modulation (PWM) sprayer. Dicamba and glufosinate were applied post-emergence (POST) to approximately 25 cm t Palmer amaranth (*Amaranthus palmeri* S. Wats.) at labeled rates of 0.28 kg ae ha^{-1} and 0.45 kg ai ha^{-1}, respectively. Droplet size and carrier volume treatments were compared using visual estimations of weed control, weed mortality, and weed dry biomass production. data were subjected to ANOVA using a mixed effect model, and means were separated using Fisher's Protected LSD Test with α=0.05. Glufosinate and dicamba had a droplet size by carrier volume interaction for visual ratings of weed control and weed mortality at data collection timings and for weed dry biomass per plant. A trend across analyses for glufosinate demonstrated that the 47 L ha^{-1} carrier volume controlled Palmer amaranth better than the 187 L ha^{-1} carrier volume when sm droplets (≤300 µm) were sprayed. However, when the droplet size increased (≥450 µm) the 187 L ha^{-1} carrier volume increased Palmer amaranth control compared to the 47 L ha^{-1} carrier volume. Interestingly, another trend for analyses of dicamba treatments had ittle to no effect on visual ratings of weed control, weed mortality, and weed dry biomass per plant were observed for either 47 or 187 L ha^{-1} carrier volumes across the range of droplet size treatments from 150 to 750 µm. However, severe weed control penalties were observed for the 900 µm spray droplet treatment. Visual ratings of weed control and weed mortality were reduced by nearly 75% and 20% and dry weed biomass increased by nearly 30 and 12 g plant^{-1} for the 47 and 187 L ha^{-1} carrier volumes, respectively, compared to the other spray droplet size treatments. Therefore, the optimum droplet sizes for Palmer amaranth control with glufosinate were 300 and 450 µm sprayed at 47 and 187 L ha^{-1}, respectively, with observed losses in weed control when spray droplet sizes were larger than 600 µm. Dicamba had a large range of optimum droplet sizes for Palmer amaranth control (between 150 to 750 µm) sprayed at either 47 or 187 L ha^{-1}. However, a critical droplet size was reached and severe weed control losses were observed with 900 µm droplets, especiy when sprayed at 47 L ha^{-1}.

EVALUATION OF DROP SIZE SPECTRA OF SPRAY NOZZLES AND TANK MIXES PROPOSED FOR USE WITH THE ROUNDUP XTEND CROP SYSTEM. Thomas B. Orr*[1], Collin E. Beachum[2]; [1]Monsanto Company, St Louis, MO, [2]Monsanto Company, St. Louis, MO (211)

A series of wind tunnel studies were conducted to determine the effects of nozzle selection and spray solution composition (i.e., tank mixes containing XtendiMax™ with VaporGrip™ Technology) on spray droplet size distributions. The resultant spray droplet size distributions were compared to a spray droplet size distribution that is representative of conditions from a field spray drift deposition study conducted with XtendiMax™ with VaporGrip™ Technology. The results of these studies suggest that additional nozzles and tank mixes can be used with XtendiMax™ with VaporGrip™ Technology without increasing drift potential relative to the conditions tested in a field spray drift deposition study conducted with XtendiMax™ with VaporGrip™ Technology.

INVESTIGATION OF NOZZLE EROSION FROM COMMERCIAL APPLICATION EQUIPMENT, A MULTI-YEAR APPROACH. Andrea Clark*, Lillian Magidow; Winfield United, River Fs, WI (212)

A commercial sprayer was outfitted with an entire boom of new AIXR11005 spray nozzles to measure nozzle erosion throughout a single spray season as well as a year to year effect. nozzles were subjected to three preliminary tests: 1) measuring flow rate with a volumetric pitcher and stop watch 2) measuring the area of the nozzle orifice with a Dyno-Lite Digital Microscope and 3) measuring droplet size, specificy investigating droplets below the size of 105 microns (µm), using a Sympatec laser system utilizing light diffraction to determine droplet size. Nozzles on four sections of the boom are changed out annuy to measure nozzle erosion within a given season. Another four sections of nozzles are replaced on the same section of boom year after year to measure cumulative erosion effects when nozzles are not changed out in a timely manner. After the first spray season, nozzles were re-tested via the testing matrix described. Notable changes were seen in VMD, percentage of volume of spray under 105µm, and flow rate after one spray season. The same commercial sprayer was again outfitted with four boom sections of new nozzles to show a new season's worth of wear, and four boom sections of the previously used nozzles to continue measuring multi-year, cumulative erosion.

APPLICATION TECHNOLOGY UPDATE. Robert E. Wolf*; Wolf Consulting & Research LLC, Mahomet, IL (213)

Modern commercial application systems (sprayers) today are bigger, faster, and can cost nearly $400,000 and depending on the added technology, could be over $500,000. Many of the technologies to be reported in this paper are not new, but have renewed interest for various reasons. Pulse-width modulation (PWM) has been one part of this added technology for twenty plus years. The technology was developed by Ag Engineering researchers at the University of CA-Davis and was later sold to Capstan. Now known as CapstanAG, they began marketing this technology and eventuy were able to get it added as a factory inst on the Tyler Patriot. CASE IH bought Tyler soon after that and kept the agreement to factory inst PWM on the Patriot sprayer. The technology is sold as AIM Command™ (regular PWM) and AIM Command Pro™ (Pinpoint and turn compensation). CapstanAG's latest version, PinPoint II™, was released in 2016. As a side note, the Patriot sprayer is celebrating twenty-five years in 2016. When CapstanAG began marketing PWM on the Patriot, no other sprayer OEM's were interested in using this technology. The comments at that time reflected that PWM would not become a valuable tool for use in the application industry. Now that the patent has expired with CapstanAg's version of PWM, other companies have entered the market. Raven has introduced the Hawkeye® Nozzle control system and just this past summer, John Deere has announced the release of a pulsing technology referred to as ExactApply™ Intelligent Nozzle Control. Both systems are based on solenoid flow control valves, in some respects similar to the CapstanAG system. The Raven system has one noted difference; in the current configuration it contains an electronic chip inside the valve module. The JD system contains two flow control solenoids and uses a 5-

nozzle turret to deliver the spray solution. It will be available for testing in 2017 and commerciy available on John Deere sprayers in 2018. Case IH is now adding the Hawkeye™ system, marketed as AIM Command FLEX™, to Patriot sprayers.

Another technology that is resurfacing as a popular add-on to a sprayer is direct injection (DI). Again, several years ago this technology was not adapted for use on agricultural sprayers. It was deemed too expensive. Now, as interest is peaking for options to spray buffer zones and field boundaries when applying the new technological advanced dicamba and 2-4,D formulations, direct injection is being considered to help with this process. Direct injection also provides better options for spray system cleanout as concerns about spraying contaminated tank mixes to non-tolerant crops will be an issue. Two new technologies that are gaining popularity have been introduced by 360 Yield Center. Equipment is available to add to spray systems to accomplish two very applications tasks. One is the Undercover™ system and the other is the Y-Drop™ system. Undercover is being utilized to add fungicides, insecticides, and crop nutrients into the canopy of a growing corn or soybean crop. The design allows for the precise placement of these materials into the critical part of the plant canopy and in a timely fashion. The Y-Drop technology allows for the placement of liquid nitrogen at the base of the corn plant directly over the plants root mass at a more critical time than with past nitrogen applications strategies. Both of these technologies require a high-clearance sprayer, especiy in corn. Several sprayer manufacturers are designing sprayers for added clearance with the frame and boom for work in ter corn in later growth stages.

INTRODUCTION OF STRIKELOCK; A NOVEL ADJUVANT SYSTEM. Ryan J. Edwards*[1], Gregory K. Dahl[1], JoAnna A. Gillilan[2], Raymond L. Pigati[3], Andrea Clark[1], Eric P. Spandl[3], Joe V. Gednalske[1]; [1]Winfield United, River Fs, WI, [2]Winfield United, Springfield, TN, [3]Winfield United, Shoreview, MN (214)

The performance of certain herbicides is increased with the use of oil-based adjuvants. However, oil adjuvants are not recommended for use with glyphosate due to proven antagonism. Methylated Seed Oil-High Surfactant Oil Concentrates (MSO-HSOC) are a newer generation of oil-based adjuvants. MSO-HSOC (e.g. Destiny® HC and Superb® HC) are classified as containing 25-50% w w^{-1} surfactant with a minimum of 50% w w^{-1} oil. MSO-HSOC have shown excellent compatibility with glyphosate while providing equivalent performance as other oils. StrikeLock™ is a new, novel MSO-HSOC adjuvant that provides optimal weed efficacy similar too other MSO-HSOC adjuvants with the included benefit of decreased drift and deposition properties. Drift performance testing of StrikeLock™ showed a decrease in fine production comparable to other commercial drift reduction agents. Field trials were also conducted across the United States on multiple crops and weeds to determine performance of many hydrophobic herbicides. In field trials, StrikeLock™ provided similar to better weed efficacy as compared to similar MSO-HSOC adjuvants.

VAPORGRIP TECHNOLOGY; HOW IT WORKS AND ITS BENEFITS. Alison MacInnes*; Monsanto Company, St Louis, MO (215)

Monsanto Company has developed formulations containing dicamba for use in the Roundup Ready® Xtend™ Crop System. XtendiMax™ with VaporGrip™ technology is a dicamba standalone formulation based on the diglycolamine (DGA) dicamba salt. Roundup Xtend™ with VaporGrip™ technology is a pre-mix formulation containing DGA dicamba and monoethanolamine (EA) glyphosate delivering a 2 to 1 ratio of glyphosate to dicamba. Both formulations contain proprietary VaporGrip™ technology that reduces the potential of dicamba volatility compared to current commercial dicamba formulations. VaporGrip technology works by preventing the formation of the volatile species in the formulation. Although volatility is a small contributor to potential off-target movement, this often remains a concern from growers and applicators as a legacy from use of the dimethylamine (DMA) salt launched in the 1960s. The DGA salt of dicamba consistently shows low volatility potential, and this can be reduced further by using VaporGrip™ technology. Spray drift and tank contamination are the main contributors to potential off-target movement. These can be decreased ly through appropriate application practices and proper tank clean-out. Application requirements for on-target applications will appear on approved herbicide product labels.

DETERMINING THE EFFECT OF ADJUVANT ON DICAMBA VOLATILITY IN A CONTROLLED ENVIRONMENT. Jamie L. Long*, Julie M. Young, Bryan Young; Purdue University, West Lafayette, IN (216)

The mitigation of off-target plant injury from dicamba will be paramount with the commercialization of dicamba-tolerant crop. In order to help combat the concern for off-target movement by vapor drift, low-volatility dicamba formulations have been developed. Further reductions in dicamba volatility may be possible through the use of adjuvants that alter either foliar absorption of the herbicide or the chemical properties of the spray deposit. In order to readily quantify the influence of adjuvant on dicamba volatility, methods have been developed for experiments using a vapor chamber within a controlled environment. The vapor chamber (similar to a 'humidome') is a clear plexiglass box with a removable transparent lid designed to adequately hold greenhouse plants and serve as the environment for volatilization to occur. Each end of the vapor chamber, has an opening five cm from the top to ow for air exchange. Prior to placing source plants in the vapor chamber the soybean plants are grown in the greenhouse until they reach the V2 growth stage. Four herbicide treatments included a no dicamba control, dicamba alone (no adjuvant), dicamba plus methylated seed oil (MSO; 1% v v^{-1}), and dicamba plus an oil emulsion drift control agent (280 ml ha^{-1}). Dicamba was a commercial dimethylamine salt formulation applied at 560 g $^{ha-1}$. Within 5 minutes of the herbicide application the source plants were transported to assigned vapor chambers. Downstream from the sprayed plants (source) a set of non-sprayed soybean plants were placed to serve as bio-indicators of dicamba vapor in the air stream. The vapor chambers were then placed in a growth chamber that has a set temperature, relative humidity, and light regime depending on the experiment. Once placed in the growth chamber, a glass tube containing filter paper and two layers of sorbent to capture dicamba vapor was attached to one of the openings and connected to a vacuum calibrated to pull air through each vapor chamber at 2 L/min. This allows for a complete exchange of air every 20 minutes. Following a 24-h incubation period, the glass tube was removed, sealed, and later extracted in methanol for a 24-h period. The source plants were discarded and the bio-indicator soybean plants were returned to the greenhouse for the development of plant injury symptoms from any dicamba volatility. Samples were assayed using LC/MS to quantify the amount of dicamba that volatilized from the plant surface. Visual estimates of soybean injury were recorded on the bio-indicator soybean plants using a scale adapted from Behrens and Lueschen (1979) at 7, 14, and 21 d after treatment (DAT). Dicamba volatility from herbicide treatments was evident. However, the addition of MSO reduced the amount of soybean injury compared to either dicamba alone or with the addition of the oil-emulsion drift control agent.

RAMIFICATIONS IN APPLYING VOLATILE GROWTH REGULATOR HERBICIDES. Donald Penner*, Jan Michael; Michigan State University, East Lansing, MI (217)

The factors that can affect the volatility of growth regulator herbicides are numerous and many are amenable to evaluation by bioassay. At the time of herbicide application a percentage of the spray may be deposited on soil and a percentage on plant foliage. Both soil type, foliage architecture and abundance can vary. Adjuvants in the spray solution could increase or decrease herbicide volatility. The diglycolamine salt of dicamba was applied to two different soils in greenhouse studies. Dicamba volatility was evaluated with a bioassay using tomato plants. Volatility differences from the soil types tested was not observed. Maximum injury for dicamba volatility was observed 14 d after initial exposure. Foliarly applied adjuvants that increase dicamba injury appeared to decrease volatility. When they were applied to bare soil they appeared to increase volatility injury from dicamba vapors.

COMPARISON OF TANK CLEANING PRODUCTS TO REMOVE RESIDUES OF AUXIN-TYPE HERBICIDES FROM SPRAY EQUIPMENT. Thomas C. Mueller*[1], Mark L. Bernards[2]; [1]University of Tennessee, Knoxville, TN, [2]Western Illinois University, Macomb, IL (218)

With greater complexity of herbicide use patterns, tank contamination will be a growing challenge to pesticide users. A search of the refereed literature found no citations on this topic. An overview of the method consists of applying a known amount of herbicide to simulated tank parts (in this study EPDM sheets which would be comparable to hose material used in some commercial spray equipment), allowing that material to dry, removing them with various tank cleaner treatments, and quantifying the difference using chemical assay. Preliminary studies showed that physically abrading the EPDM surface altered pesticide adherence to the EPDM sheet. For this study we conducted separate studies with dicamba or 24D (both at normal field use rates) plus glyphosate at 1.1 kg a.e. ha^{-1} in the spray mixture of 94 l ha^{-1}. The tank parts were placed into a fume hood and 1.0 mL of the spray solution was added in 16 to 24 drops to the top of each tank part. These were then allowed to dry in a fume hood for approximately 12 hours at room temperature. Tank cleaners were prepared by adding 0.25% v v^{-1} per label instructions (this was 1.0 ml into 400 mL). Each 5*10 cm EPDM sheet was inserted in 400 mL of each respective tank cleaner for 5 seconds. An aliquot of the tank cleaner water was diluted for later analysis on LCMS for each respective herbicide. Another data point measured was the pH of the tank cleaner solution. There were statistically different pHs and recoveries from the various tank cleaners. All treatments were also compared to a control treatment where the initial 1.0 mL of herbicide mixture was placed directly into a 1000 mL bottle as a comparison. For dicamba, the order of most effective tank cleaners was FS Rinseout ≥ Ammonia = water alone > Purus = All Clear = Neutralize = Wipeout = Innvictis. For 2,4-D choline salt the order starting with most effective was FS Rinseout = Ammonia = water only ≥ Innvictis > Purus = All Clear = Neutralize = Wipeout. This data indicated only minor benefits of using the commercial tank cleaners, although further studies on different tank components still need to be conducted.

HERBICIDE DEPOSITION ON GLYPHOSATE-RESISTANT GIANT RAGWEED AND HORSEWEED AS INFLUENCED BY SPRAY NOZZLE DESIGN. Travis Legleiter*, Bryan Young, William G. Johnson; Purdue University, West Lafayette, IN (219)

Concerns of spray particle drift onto sensitive species has prompted the requirement of nozzles that produce very coarse to ultra coarse droplets and reduced driftable fines for post-emergence herbicide applications associated with the use of new herbicide-resistant soybean traits. Experiments were conducted in Indiana in 2015 and 2016 to evaluate herbicide deposition and coverage on glyphosate resistant- horseweed (*Conyza canadensis* (L.) *Cronq.*) and giant ragweed (*Ambrosia trifidia L.*) as influenced by broadcast spray nozzle designs. Glyphosate plus 2,4-D and glyphosate plus dicamba were applied to 10- to 20-cm t weed species in 38-cm row soybean with two traditional flat fan nozzles: TeeJet brand Extended Range and Turbo TeeJet; and two drift reduction nozzles: Air Induction Extended Range and Turbo TeeJet Induction. Applications were made with an ATV sprayer traveling 19 km hr^{-1} equipped with 11004 nozzles at a pressure of 276 kPa. Fluorescent and foam marker dye were added to the spray solution prior to application for evaluation of herbicide deposition on leaf surfaces and Kromekote cards, respectively. Deposition density on the Kromokote cards was less with the two drift reduction nozzles as compared to the Turbo TeeJet and Extended Range nozzles regardless of weed species. Deposition of spray solution onto the target weed species ranged from 0.3543 to 0.7184 ul cm^{-2}. Differences between nozzle types were not despite the differences in deposition density observed on the Kromekote cards. The data collected in this research has demonstrated that drift reduction nozzles may not reduce herbicide efficacy, as spray solution deposition onto the target weed surfaces was equivalent across broadcast nozzle types.

HORSEWEED MANAGEMENT IN THE EASTERN CORNBELT. Stephanie DeSimini*[1], William G. Johnson[2], Mark Loux[3], Tony Dobbels[3]; [1]Purdue University, West Lafayette, IN, [2]Purdue, West Lafayette, IN, [3]Ohio State University, Columbus, OH (220)

Horseweed (*Conyza canadensis*) has been become increasingly problematic due to its life cycle and the rapid spread of glyphosate- and ALS-resistant biotypes. The presence of horseweed in soybean fields can reduce yields up to 83%, making it a priority to control across the Midwest. The objective of this study was to determine the influence of various dicamba and 2, 4-D programs on horseweed control. Field trials were conducted in 2015 and 2016 at the Southeast Purdue Agricultural Center in Butlerville, IN. Treatments were applied in both the f and spring to compare PRE and POST applications. In 2015 the dicamba-based treatments were successful when applied at various times and combinations resulting in greater than 90% control by August 5th. The only treatment that provided poor control for the dicamba-based treatments was the treatment using Roundup Powermax alone, applied in late May and late June, providing only 68% control by August 5th. The 2015, 2,4-D-based treatments provided control as low as 64% the first assessment date on July 1st, but proved to be mostly effective by the last assessment date with control above 90% by August 5th. The dicamba-based applications in 2016 provided adequate control of greater than 90% by 26 July, except when applications were limited to very late in season which resulted in control as low 60%. In 2016 the 2,4-D-based programs provided variable results with control as low as 36% in late-season applied herbicides, and up to 99% control in early- and late-season applications. Best over control was provided by treatments that included both fall and spring treatment combinations of dicamba and glyphosate or 2,4-D and glyphosate.

DO ALS-INHIBITING HERBICIDES HAVE ANY VALUE WHEN TARGETING FIELDS WITH WEEDS RESISTANT TO THOSE HERBICIDES? Jodi E. Boe*, Bryan Young, Haozhen Nie; Purdue University, West Lafayette, IN (221)

The increase in the prevalence of herbicide-resistant weeds has raised concern over the utility of herbicides in the present and future. This is especiy true for herbicides that have many weed species that have evolved resistance, such as the acetolactate synthase (ALS)-inhibiting (group 2) class of herbicides. The extent of weed resistance to group 2 herbicides has contributed to the mindset that group 2 herbicides have little value in managing weed populations today. Herbicides from other sites of action with weed resistance have been shown to still provide some level of field efficacy, especiy if the resistance mechanism has been characterized to enable low- to moderate-level resistance. More specificy, soil residual applications of some PPO-, HPPD-, and photosystem II-inhibiting herbicides have been reported to contribute ly to field-level management of some weed biotypes classified as resistant to post-emergence applications of these herbicides. Anecdotal evidence would suggest that some group 2 herbicides may also result in greater efficacy when applied preemergence (PRE) compared to post-emergence (POST) on group 2-resistant weed populations. Is this a result of the proportion of individuals in the soil seedbank that remain sensitive to group 2 herbicides or an observation that would suggest some group 2-resistant individuals may maintain a level of sensitivity to group #2 herbicides applied through soil residual? Field research was conducted to determine if the efficacy of ALS-inhibiting herbicides is influenced by the application method (PRE vs. POST) to a field containing t waterhemp with resistance to ALS-inhibiting herbicides. Herbicide applications included three rates of chloriumuron-ethyl (11.2, 1.28, and 2.56 g a.i. ha^{-1}) and one rate of imazethapyr (70.6 g a.i. ha^{-1}) applied PRE and POST (5 to 10 cm of weed height). Since the field also contained t waterhemp with resistance to PPO-inhibiting herbicides fomesafen was included as a comparison herbicide where soil residual applications provide greater efficacy than POST applications on t waterhemp with resistance to PPO-inhibiting herbicides. Visual estimates of control were recorded at 14, 21, 28, 35, and 38 d after treatment (DAT). Weed counts were taken in four $0.1m^2$ quadrats in each plot at 1 DAT (POST) and 14 DAT (POST). Quadrat position was marked to ensure counts were taken on the same area at each evaluation. At the POST 14 DAT timing, biomass was collected from each marked quadrat. Chlorimuron-ethyl and imazethapyr resulted in greater efficacy on t waterhemp when applied as a soil residual compared with a post-emergence application. Thus, these preliminary results would suggest there could be utility of group 2 herbicides for managing t waterhemp with resistance to group 2 herbicides if applied as a soil residual instead of post-emergence. Current and future research will further quantify and characterize the contribution of ALS-inhibiting herbicides on field management of tall waterhemp and other problematic weeds with resistance to group 2 herbicides.

WINTER COVER CROP SPECIES, SEEDING RATE AFFECTS WINTER ANNUAL WEEDS. Erin Haramoto*; University of Kentucky, Lexington, KY (222)

Winter annual cover crops can offer many benefits, including competing with winter annual weeds. Depending on the termination time and amount of biomass accumulated, cover crop residues may also suppress weeds in the following cash crop. An experiment was conducted in Lexington, KY to determine the relative impacts of cover crop species (wheat vs. cereal rye), seeding rate (high rate, 112 kg ha^{-1}, vs. low rate, 34 kg ha^{-1}), and planting method (drilled vs. broadcast) on the competitive ability of the cover crop against winter annual weeds and the in-season weed suppression in a following soybean crop. Cover crops were seeded following corn harvest in October 2015. Weed density, weed biomass, and cover crop biomass was sampled on April 14, 2016; glyphosate was applied the following day. Soybeans were planted on May 24, 2016, on 38 cm rows; weed density in the soybeans was measured one week later and at the end of the season. This experiment is currently being repeated. More cover crop biomass was produced with the high seeding rate of cereal rye; the low seeding rate of cereal rye produced similar amounts of biomass as the two seeding rates of wheat. Planting method did not affect cover crop biomass accumulation. Winter annual weed biomass was lowest in the treatment with the high seeding rate of cereal rye. The low seeding rate of cereal rye had lower weed biomass than plots with no cover crop, though similar to plots with wheat regardless of seeding rate. None of the experimental treatments affected the density of early-emerging summer annual weeds on 4/14/16; these included mostly giant ragweed. cover crop treatments reduced weed density one week after soybean planting relative to the no cover crop control. Seeding rate had a larger influence than the other factors, regardless of the amount of residue produced. Soybean yield, adjusted to 13% moisture, averaged 4.1 metric tons ha^{-1} (61 bushels/acre) and did not differ between treatments.

A DRAFT GENOME OF *KOCHIA SCOPARIA*. Eric L. Patterson*[1], Karl Ravet[1], Dean Pettinga[1], Phil Westra[1], Dan Sloan[1], Chris Saski[2], Todd A. Gaines[1]; [1]Colorado State University, Fort Collins, CO, [2]Clemson University, Clemson, SC (223)

Kochia scoparia (kochia) is one of the most important weeds in the western United States and Canada. It currently infests hundreds of thousands of acres of farm and range land across North America and causes millions of dollars in crop loss annuy in sugar beet, canola, wheat and corn fields. Kochia has evolved resistance to many herbicides used for its control, including glyphosate, dicamba, and ALS-inhibitors. Additiony, Kochia is an extremely hardy plant that can tolerate substantial abiotic stress from drought, salt, and both extremes of temperature. This suite of traits contribute to its success as a weed. Our research aims to make kochia a model organism, not only for weed research but also as a plant extremophile. Initial analysis of Illumina reads suggested that the Kochia genome is highly complex. To circumvent problems surrounding highly repetitive regions of the genome we are utilizing a hybrid low coverage PAC-BIO and high coverage Illumina approach. Currently, we have assembled ~69% of the genome with 591 mb in 34536 scaffolds using an Illumina-only -Paths assembly and ~75% of the genome with 641 mb in 20k scaffolds using an PAC-BIO-only Canu assembly. We are currently integrating these assemblies to complement each other. Our initial -Paths assembly suggests that kochia undergoes substantial gene duplication throughout the genome and that this may lead to rapid genome evolution and increased genetic diversity at key loci involved in abiotic stress response.

MODELLING POLLEN-MEDIATED GENE FLOW FROM HERBICIDE-RESISTANT WEEDS: COMMON WATERHEMP AS AN EXAMPLE. Debalin Sarangi*[1], Andrew J. Tyre[1], Eric L. Patterson[2], Todd A. Gaines[2], Suat Irmak[3], Stevan Knezevic[4], John Lindquist[1], Amit J. Jhala[1]; [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Colorado State University, Fort Collins, CO, [3]University of Nebraska–Lincoln, Lincoln, NE, [4]University of Nebraska-Lincoln, Concord, NE (224)

Gene flow is a key component for plant evolution; however, the role of gene flow in spreading herbicide-resistant traits among weed populations is poorly understood. The dioecy and animophilous nature of common waterhemp is considered to promote rapid spread of herbicide resistance genes in an agricultural landscape. Field experiments were conducted in Nebraska in 2013 and 2014 to quantify pollen-mediated gene flow (PMGF) from glyphosate-resistant (GR) to -susceptible (GS) common waterhemp using a concentric donor-receptor design. A power analysis using binomial probabilities was performed to estimate the minimum sample size to accept the outcome at a certain level of confidence. A total of 131,295 common waterhemp plants (F_1, GR × GS) were screened in the greenhouse and a minimum power of 0.95 ($\alpha = 0.05$) was ensured. Frequency of gene flow data were subjected to nonlinear regression using Generalized Nonlinear Models (package *gnm*) in R, where the gene flow varied with distance from the pollen source, direction of the pollen-receptor blocks, average wind speed, wind frequency, wind run, and year. Therefore, 62 possible models were constructed and compared using the Akaike's Information Criterion (AIC). The best candidate model was a double exponential decay function in which the independent variables were distance from the pollen source, the direction of the pollen-receptor blocks, and the year. The distances, where PMGF was declined by 50% (O_{50}) and 90% (O_{90}), were estimated as 2.5 m and 88.0 m, respectively. The gene flow was highly variable among different directions and years; therefore, it was important to develop a statistical model including these variables in a single model. The novel statistical approach used in this study for modelling the PMGF can also be adopted in future to detect the transgene flow from geneticy modified crops. The results from this study also critical to explain the rapid spread of GR common waterhemp in the midwestern United States.

HUMIDOME: A NEW METHOD TO DETERMINE VOLATILITY OF PESTICIDES. Walter K. Gavlick*; Monsanto, St Louis, MO (225)

In this presentation, a laboratory-based method to determine the relative volatility of herbicide formulations will be described. An herbicide formulation is applied to a substrate in a closed dome system, the closed-dome is placed into a temperature and humidity controlled chamber, and air is drawn through the closed dome for twenty four hours. The volatile analyte in the formulation is trapped on a piece of polyurethane foam (PUF) during this time period. The analyte is solvent extracted from the PUF and the extract is analyzed by liquid chromatography-mass spectrometry / mass spectrometry (LC-MS/MS). Details of the experimental setup and representative relative volatility data will be presented.

Author Index

Keyword Index

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