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The Western Society of Weed Science dedicates our proceedings in memoriam to Dr. Steve Miller and Dr. Roland Schirman, for their years of service to the society.

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2024

PROCEEDINGS

OF

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PREFACE

The Proceedings contain the written abstracts of the papers and posters presented at the 2024 Western Society of Weed Science Annual Meeting plus summaries of the research discussion sections for each Project. The number located in parenthesis at the end of each abstract title corresponds to the paper/poster number in the WSWS Meeting Program. Authors are indexed separately. Index entries are published as received from the authors with minor format editing.

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The Minutes of the Board of Directors meetings and the Business Meeting are available at the WSWS website.

The WSWS would like to thank André Lucas Simões Araujo – Colorado State University who graciously volunteered his time and talents to furnish many of the award photographs included in this publication.

Proceedings Editor: Carl Libbey

GENERAL SESSION

Introductions and Announcements. Timothy Prather*; University of Idaho, Moscow, ID (168)

Abstract not available

WSWS Presidential Address. Curtis Rainbolt*; BASF Corporation, Meridian, ID (169)

The Archaeology of the Mesa Verde Region. Susan Ryan*; Research Institute, Crow Canyon Archaeological Center, Cortez, CO (170)

The Mesa Verde region of southwest Colorado is a land of spectacular contrasts, where deep sandstone canyons dissect sage-covered plains, all against the distant backdrop of the San Juan Mountains, which are part of the Colorado Rocky Mountains. Cold, snowy winters give way to hot, dry summers, and periods of relatively abundant moisture are punctuated by sporadic but sometimes prolonged periods of drought. Living off the land has always been, and continues to be, a challenge, but one that people through the ages have met with extraordinary ingenuity and resilience. From the arrival of Ice Age hunters to the introduction of agriculture and eventually the creation of modern cities and towns, the story of how Indigenous peoples have adapted to, and flourished in, the Mesa Verde region is one of the most fascinating stories in human history. And it is a story that continues to unfold, as archaeologists continue to make discoveries that shed new light on ancient human behaviors and their relevance to modern societies.

Science for a Changing World: Applications in the Colorado River Basin. Katherine Dahm*; U.S. Geological Service, Rocky Mountain Region, Denver, CO (171)

Leading science organizations worldwide continually improve their science and deliver high-quality, actionable information to society. As organizations seek opportunities to add value and enhance the benefits of their science, interactions between humans and the environment continue to increase the complexity of societal grand challenges. Drought impacts are complicated and multifaceted and are typically classified as economic, social, and environmental. Monitoring, analyzing, and predicting drought impacts is particularly challenging due to compounding factors, including climate change, wildfire, landscape change, and infrastructure risks. Furthermore, climate change projections indicate increased drought frequency, making drought a crucial issue in key landscapes such as the Colorado River Basin. The U.S. Geological Survey (USGS) has a diverse suite of drought-related expertise and ongoing research that is strengthened by partnerships with other agencies and stakeholders. This capacity is built across multiple disciplines to provide monitoring, analyses, and predictions to fulfill stakeholder science needs. This presentation explores how the USGS is approaching landscape science for a changing world.

Washington DC Update. Lee Van Wychen*; WSSA – Executive Director of Science Policy, Alexandria, VA (172)

Abstract not Available

POSTER SESSION

WSWS Project 1. Weeds of Range, Forestry, and Natural Areas

Assessing the Effectiveness of Plant Identification Apps During Invasive Plant Surveys. Daniel J. Coles*[1], Chelsea-Victoria F. Turner[2], Kelsey C. Brock; [1]University of Wyoming/Plant Sciences Department, Laramie, WY, [2]University of Wyoming - Plant Sciences, Laramie, WY (001)

With the ongoing development of image recognition technology and its use in digital plant identification, it is important to consider its applications in invasive plant surveys. The objective of this study was to determine if plant apps can identify native and non-native species within four of Wyoming's major plant families: the Asteraceae, Brassicaceae, Amaranthaceae, and Poaceae. We used PictureThis, PlantSnap, PlantNet, LeafSnap, Google Lens, and iNaturalist Seek and compared their accuracy across 110 sets of plant specimen images. Images included pictures of the plant's flowers, leaves, and habit. We found that 1) PictureThis was the most accurate app overall (57.63% accurate), with the exception being the Brassicaceae family, 2) There is significant variation in accuracy among plant families, and 3) Pictures containing images of the plant's flowers are more likely to receive an accurate ID. These results indicate that accuracy of a correct identification continues to remain inadequate to the species level regardless of the app used. Accuracy to the genus level (82.88% for PictureThis) seems to be more promising and can give users a place to start for further validation using dichotomous keys. This study's findings emphasize the continued need for identification validation by either an expert in the field or with the use of dichotomous keys while conducting invasive plant surveys as a wrong identification can potentially lead to the further dispersal of a non-native species, and therefore an opportunity to out-compete native species.

A Case for EDRR in Wyoming. Caroline M. Kittle*[1], Kelsey C. Brock[2]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming - Plant Sciences, Laramie, WY (002)

Non-native invasive plants pose risks to agriculture, native biodiversity, and ecosystem health. Early Detection and Rapid Response (EDRR) is a tactic used to mitigate their impacts and decrease the cost of action. To identify and adequately respond to new invasions early in their timeline, however, it is vital to gather a baseline of information to inform surveying efforts. Invasive species watchlists are one such solution; here, we combed occurrence data to identify species at the doorstep, though not quite inside the borders, of Wyoming. Using state checklists of invasive plants, as well as noxious weed lists, we identified occurrence records of non-native species in Wyoming and its border states. Records were then isolated according to whether they occurred within 100 km of a border of Wyoming, within a county within 100 km from a border of Wyoming, or in counties directly on the border with Wyoming. From there, we created species watchlists not only at the state level but also for all twenty-three counties within Wyoming. The analysis produced a list of 441 species within 100 km of the border of Wyoming (with 6.35% considered noxious to a state in the region), and an average of 368.46 species within 100 km of the borders of any given county (with 15.15% considered noxious). These lists will be used as a stepping point for field surveys, so that new species can be detected and eradicated before they have the chance to become established threats to Wyoming's lands.

Invasive Annual Grass Control on Rangelands with Indaziflam. A. Mealor*[1], Jaycie N. Arndt[2], Beth Fowers[3], Chloe M. Mattilio[3], Claire F. Visconti[3]; [1]University of Wyoming Sheridan Research and Extension Center, Laramie, WY, [2]University of Wyoming, Arvada, WY, [3]University of Wyoming, Sheridan, WY (003)

Indaziflam is a root growth-inhibiting herbicide that is rapidly being adopted to manage invasive annual grasses across rangelands of the western U.S. Its use on grazed rangelands was approved by EPA in 2020, so researchers and practitioners alike are still learning about its performance in various settings. As with any new tool, specific use case characteristics and attributes of the system in which it is being used may affect responses and best approaches for management. Statements in the peer-reviewed literature ranging from "Indaziflam may allow for the proactive interventions that prevent the 'downward spiral' of cheatgrass invasion and repeated wildfire that has challenged rangeland managers for decades" to "aboveground and seedbank community composition was negatively impacted by indaziflam, and these effects were strongest for native annual forbs." The purpose of this summary analysis is to summarize the current state of documented knowledge on indaziflam's use in managing invasive annual grasses in rangelands. We used a summary analysis approach to evaluate field data from more than 50 published and nonpublished rangeland trials to assess trends and consistency in weedy annual target species and perennial grass responses. While we discovered subtle differences depending on basis of treatment response (cover, biomass, etc.), tank-mix herbicide partners, and season of application (Spring, Summer, Fall), several consistent trends were identified. Functional group responses were highly consistent with high reduction of annual targets and marked increases in perennial grasses after treatment. Within-season annual grass reduction and perennial grass increases were greater with indaziflam + imazapic than with indaziflam alone. Our summary analysis indicates that indaziflam's ability to control annual weedy species and increase perennial grasses is robust across a wide variety of systems, but more information is needed to evaluate species-specific responses.

Seed Ecology of the Invasive Malta Starthistle (*Centaurea melitensis*) and Implications for Management. Talia J. Humphries*; Texas A&M University, College Station, TX (004)

Abstract not Available

Weed Suppression in Rangeland and Natural Areas Utilizing Native Grasses. Liberty B. Galvin*[1], Zhenglin Zhang[2]; [1]Oklahoma State University, Stillwater, OK, [2]University of California Davis, Davis, CA (005)

The proliferation of weedy species poses a significant challenge in rangelands and natural areas, leading to the deterioration of livestock feed quality, a decline in biodiversity, and overall ecological disruption. Utilizing native grasses for weed control emerges as an ecologically sensible strategy, offering a sustainable and low-input approach over extended periods. This study undertook a systematic literature review to investigate the dynamics between native grasses and weeds, revealing the potential of native grasses to mitigate weed presence through interactions with other biological communities. The research advocates for the integration of agronomic and breeding techniques with restoration initiatives, including the implementation of specialized seeding methods for the successful establishment of native grasses. A comprehensive planning

framework for land managers is proposed, underscoring the importance of considering functional traits for competitive advantages against weeds and prioritizing germplasm availability during species selection. Additionally, the study delves into management strategies that favor native grasses, such as land clearance and strategic disturbances. Weed suppression mechanisms encompass direct competition, indirect interactions through trophic levels of arthropods and grazers, and human-induced disturbances. The study's outcomes support the contention that, when employed thoughtfully, native grasses have the potential to play a pivotal role in effective weed suppression.

Factors Influencing Plant Response to Indaziflam. Maggi E. Mathews*[1], Weston Maughan[2], Mirella F. Ortiz[1], Eric P. Westra[1], Corey V. Ransom[1]; [1]Utah State University, Logan, UT, [2]Washington State University, Pullman, WA (006)

Indaziflam is a pre-emergent herbicide that has been increasingly used in natural areas for controlling invasive annual grasses. Due to indaziflam's soil residual activity it can negatively impact the successful establishment of desirable species for revegetation purposes. This study aims to evaluate the use of carbon banding to improve the establishment of desirable species in the field, as well as evaluating the role of indaziflam inhibition on their root growth. Siberian wheatgrass (Agropyron fragile) and small burnet (Sanguisorba minor) were seeded into half flats (22.9 by 22.9 cm) with 20 cm rows and 1.25 cm spacing. Activated charcoal was sprayed in a 2.54 by 22.9 cm band over the seeded rows at 9 different rates, ranging from 0-336 kg ha^{-1}. Using a spray chamber, flats were sprayed with indaziflam at a rate of 43.87 g ha^{-1}. Seedling counts from the activated charcoal experiment were recorded 3 and 4 weeks after treatment. For higher carbon rates there was no significant difference between germination for both species. Regarding root inhibition, aforementioned species were planted in 2% agarose plates, with 9 indaziflam rates, ranging from 0-3200 pM. Seed germination and root lengths were measured at the end of the trial and their germination and growth was inhibited in a dose-dependent manner.

Ornamental Plants: Invasion Risk for Wyoming. Alexandra von Bergman*[1], Kelsey C. Brock[2]; [1]University of Wyoming, Laramie, WY, [2]University of Wyoming - Plant Sciences, Laramie, WY (007)

A Weed Risk Assessment (WRA) is a vetting process for plants to help predict if a plant will become invasive. WRAs consist of 49 questions about a species' biology which are scored to determine potential for invasiveness. Acquiring the answers for these questions is done through a lengthy literature search process. Scores are ranked as Low Risk, High Risk, and Evaluate Further. While the usefulness of WRAs have been verified in multiple regions, they are extremely time consuming, taking many hours to complete. To see if Artificial Intelligence (AI) might help speed up the process while still providing accurate answers and scores, I am comparing the results of WRAs done by people and by seven different AI platforms. We have found that AI is much faster at completing WRAs than humans. However, they may not be as accurate in their answers. Depending on if a platform confidently provides a wrong answer, or admits to not knowing the answer, they could affect the weed risk score in the right or wrong direction. Comparisons to human scores will tell us if the AI platforms can be trustworthy in this process, or if they will need

to be carefully monitored when used. AI could either replace humans in the process or simply act as a research assistant.

Comparing Remotely-Sensed Invasive Annual Grass Estimates with Ground Monitoring Data at Varying Spatial Scales. Chloe M. Mattilio*[1], Brian A. Mealor[2], Jaycie N. Arndt[3], Beth Fowers[1], Claire F. Visconti[1]; [1]University of Wyoming, Sheridan, WY, [2]University of Wyoming Sheridan Research and Extension Center, Laramie, WY, [3]University of Wyoming, Arvada, WY (008)

In remote sensing, there is generally a tradeoff between spatial and temporal scales in imagery collection and availability. We evaluated the ability of multispectral imagery (blue, green, red, near infrared, and derived spectral indices) collected at different spatial and temporal scales to detect invasive annual grass (IAG) species at three sites in a mixed-grass prairie in Johnson County, Wyoming. Imagery was collected weekly from May-July of 2021, 2022, and 2023 at $5m^2$, $10m^2$, and $30m^2$ spatial resolution. The number of dates available for each imagery source differed, with 9 dates, 5 dates, and 6 dates for the $5m^2$, $10m^2$, and $30m^2$ imagery, respectfully. Our objective was to evaluate how different resolutions of multispectral imagery detect IAG presence and abundance. We used ground mapping of vegetative cover to train classification models for presence and canopy cover of combined cheatgrass (Bromus tectorum) and Japanese brome (Bromus japonicus) and standalone cheatgrass. Ground mapping locations were also interpolated to continuous IAG presence maps of study areas, which were again resampled to match the spatial resolution ($5m^2$, $10m^2$, and $30m^2$ pixels) of the three imagery sets. Overall IAG model accuracy varied by site, but a standalone cheatgrass model tended to outperform a combined cheatgrass and Japanese brome model and most accurate models were trained on full sets of imagery from all dates. This tradeoff between imagery spatial and temporal scales is not well understood, and rangeland managers and spatial scientists should consider producing IAG prediction maps that best meet their needs and specific situations.

Seedbank Suppression is Critical for Long-Term Dyers Woad Control: It's a Long Woad. Maloree J. McDonald*[1], Erin M. Hettinger[1], Eric P. Westra[1], Mirella F. Ortiz[1], Tom A. Monaco[2], Corey V. Ransom[1]; [1]Utah State University, Logan, UT, [2]USDA-ARS, Logan, UT (009)

Dyer's woad (*Isatis tinctoria* L.) is an invasive biennial forb that plagues several Western states. Its life cycle often requires repeat herbicide applications that can be expensive and have the potential to damage desirable vegetation. Our study objectives were to determine the long-term effectiveness of indaziflam, a preemergent herbicide, alone and in combination with three postemergence herbicides to control dyer's woad populations. Two research sites were established in consecutive years in Collinston, Utah to test seven herbicide treatments with a fall and spring application timing. Plots were three by nine meters arranged in a complete randomized block with four replicates. Data was collected through seedling and rosette counts and assessed using an observation-level random effects model. Data collected 18 months after treatment showed that all post-emergent treatments, alone or combined with indaziflam, reduced rosette density, while indaziflam alone did not significantly reduce rosette numbers. Seedlings were significantly reduced in plots with indaziflam alone or in combination with post-emergent herbicides. Plots treated with only post-emergent herbicides did not provide control of seedlings. Data collected

three years after treatment showed that indaziflam alone or combined with other herbicides significantly reduced both rosette and seedling density. Data from spring and fall treated plots provided variability in several herbicides' effectiveness on seedlings. Suppression of seedling recruitment is critical for long-term management of Dyer's Woad. Herbicides that disrupt the plant's life cycle by controlling seedlings may help managers more effectively manage Dyer's Woad infestations that may otherwise require continuous herbicide treatment.

Elongated Mustard Management Update in Utah. Cody J. Beckley*, Natalie L. Fronk, Eric P. Westra, Mirella F. Ortiz, Corey V. Ransom; Utah State University, Logan, UT (010)

Elongated mustard (Brassica elongata) is an invasive winter annual, biennial, or short-lived perennial increasingly common in northern Utah's cultivated farmland and rangelands. Multiple trials aimed at controlling elongated mustard in rangeland were conducted to evaluate the efficacy of various herbicides. Four trials were established near Weston, ID in 2020 on Conservation Reserve Program land in fields dominated by perennial grass species as well as in fields with perennial grasses, legumes, and weed forb species. Herbicide treatments consisted of spring and fall applications of imazamox, imazethapyr, imazapic, indaziflam, and glyphosate. Individual plots measured 3 by 9 m and were arranged in a randomized block design, replicated four times. Elongated mustard rosette and seedling density counts, and plant cover were collected using frames or point-line transects, respectively. In perennial grass fields, all herbicide treatments significantly reduce B. elongata cover and density. Elongated mustard seedling density, as well as desirable grass, legume, and forb cover were significantly increased in 2023 compared to 2022. In the mixed species fields, there was a significant year by treatment effect with increases in elongated mustard cover in 2023 for non-treated control and imazamox treatments. No treatment effect was observed on elongated mustard seedlings in 2023 possibly due to increased growth and presence of desirable vegetation. Desirable perennial grass cover was significantly increased in 2023 and was higher in plots treated with indaziflam vs the non-treated control. In 2022, weedy species cover was significantly decreased in plots containing indaziflam compared to the untreated control, but in 2023 weedy cover was similar across all treatments which may be due to increase in desirable plant cover impacted by increased precipitation compared to drought conditions in 2022. In all trials we saw no reduction in desirable cover by herbicide treatment. We also observed linear relationships between elongated mustard spring rosette density and summer cover. Trials will continue to be monitored to assess long-term elongated mustard control options and impacts on desirable plant community response in Utah.

Managing Tall Oatgrass: It's Not the Cow, It's the How Part II. Kelly T. Uhing*, Ryan Middleton, Ann Lezburg; City of Boulder Open Space and Mountain Parks, Boulder, CO (011)

Tall oatgrass is a Watch List species with the Colorado Department of Agriculture. It is an exotic, cool-season, perennial grass that is located on City of Boulder Open Space and Mountain Parks properties southwest of Boulder, Colorado. It forms a monoculture that competes against desirable native vegetation for resources including sunlight and moisture. In an effort to reduce populations and increase native grasses and forbs, tall oatgrass has been grazed consistently by cattle. Which in some areas, has been combined with herbicide applications, as well as mowing. Each pasture has been consistently monitored each year by performing plant counts and measurements as well

as utilizing established photo points. Data is showing that there is a significant reduction in tall oatgrass that has been grazed. And for plants that do come back, they are coming back at a shorter height than the previous year. This demonstrates that grazing is altering stem height and providing a stress to tall oatgrass.

WSWS Project 2. Weeds of Horticultural Crops

Exploring the Interaction of Tiafenacil with ACCase Inhibitors and Glufosinate for Italian Ryegrass Control in Hazelnut. Joshua W. Miranda*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (070)

Herbicide-resistant Italian ryegrass poses a significant and escalating challenge for weed management in hazelnut orchards, increasing management costs. Herbicide tank-mixtures have shown effectiveness in mitigating the risk of herbicide resistance. Tiafenacil, a recently registered protoporphyrinogen oxidase (PPO)-inhibiting herbicide in hazelnuts, presents potential solutions for Italian ryegrass management in orchards because of its foliar effect on monocots. While previous research demonstrated synergy in broadleaf weed control when PPO-inhibitors are combined with glufosinate, the interaction of tiafenacil with glufosinate for Italian ryegrass control remains largely unexplored in the literature. Moreover, tiafenacil interaction with acetyl-coA carboxylase (ACCase)-inhibiting herbicides is not well-documented. Mixtures of carfentrazone 35 g ai $ha^{-1}$and glufosinate 1,150 g ai ha^{-1} failed to enhance glufosinate efficacy in controlling Italian ryegrass or reducing inflorescence biomass in field studies conducted from 2022 and 2023. In contrast, combinations of tiafenacil (75 g ai ha^{-1}) with glufosinate (1,150 g ai ha^{-1}) demonstrated superior performance, effectively reducing Italian ryegrass inflorescence weight (66%) compared to herbicides applied individually. Tiafenacil 75 g ai ha^{-1}in combination with either clethodim 135 g ai ha^{-1} or fluazifop-P-butyl 420 g ai ha^{-1} improved Italian ryegrass control by 17% and 38%, respectively, and enhanced reduction in inflorescence biomass by 9% and 12%, respectively. While ACCase-inhibiting herbicides mixed with carfentrazone did not affect Italian ryegrass control. This research underscores the importance of herbicide mixtures in managing resistance and emphasizes the need for diversified approaches in weed control to safeguard hazelnut orchard sustainability.

Evaluating the Effect of Endothall-treated Irrigation Water on California Crops. Stephen C. Chang*[1], Bradley D. Hanson[2]; [1]UC Davis, Davis, CA, [2]University of California, Davis, Davis, CA (071)

Endothall is widely used as an aquatic herbicide and comes in a dipotassium (Teton®) and monoamine salt (Cascade®) formulation. Greenhouse and field studies were conducted in 2023 to evaluate phytotoxicity in California crops. Applications of Cascade® and Teton® were made at varying concentrations (0.31 to 160 ppm ai) on corn and kidney bean. No injury was observed at the tested concentrations. A subsequent greenhouse study was conducted with Cascade® and Teton® at higher concentrations (5 to 20,480 ppm ai). Necrosis and defoliation were observed on leaves that were directly treated with the herbicide at concentrations of 1,280 ppm and above.

Leaves formed after foliar treatments were unaffected. In further greenhouse studies, Cascade® and Teton® at nine concentrations (5 to 1,280 ppm ai) were applied as a soil drench on seedling corn and kidney bean. Injury was visible starting from 40 ppm as slight wilting for corn and chlorotic leaves for kidney bean. Necrosis was observed in both species and additionally defoliation in kidney bean at concentrations above 320 ppm. In a field study conducted on established almond trees, berms were erected around each tree to create 9 feet by 11 feet plots and contain the treatment within the root zone. Soil applications at five rates (1.25 to 20 ppm ai) and three volumes of water (1, 2, and 4 acre-inches of water) were applied. Simulated flood irrigation treatments were applied in July 2023 as Cascade® and in September as Teton®. No injury was observed following either application.

Evaluation of Electrical Weed Control in California Orchards. Tong Zhen*[1], Bradley D. Hanson[2]; [1]University of California, Davis - Department of Plant Sciences, Davis, CA, [2]University of California, Davis, Davis, CA (072)

Managing weeds is challenging in sustainable and organic tree crops in California. Electrical weed control (EWC) could be a new alternative for growers. The Zasso^{TM} Tractor-Based electrical weeding machine controls orchard weeds by physical contact with the applicator electrodes, which can pass electrical current to the target vegetation. This project aims to evaluate the weed control efficacy and crop safety of EWC in California orchards. In July 2023, an EWC efficacy study was conducted in a young walnut orchard. The treatments included four speed-and-power combinations. Weed cover data were collected at 5, 10, and 20 days after treatment (DAT), and the number of weeds was counted at 20 DAT. The results indicated that all the EWC treatments reduced the weed cover to less than 5% at 5 and 10 DAT, whereas the untreated plot had over 83% weed cover. The data also suggested that the different EWC treatments were similarly effective. In April 2023, a crop safety study was initiated to examine how newly planted almond trees and the soil microbial community respond to four EWC applications in one season. Four EWC treatments were applied at different speeds, power settings, and number of pass combinations. Tree trunk diameters and height were recorded at the end of the season. Soil samples were analyzed in October 2023 to measure soil microbial respiration. The tree growth and soil respiration data showed insignificant treatment effects, suggesting EWC had no impact on tree growth and biological soil health in the first year.

Weeds Present at Green Chile Harvest in the Rio Grande Valley of Southern New Mexico. Ram Singh Insa*, Brian Schutte, Erik A. Lehnhoff; New Mexico State University, Las Cruces, NM (073)

Weeds challenge chile pepper production as they negatively impact fruit yield, decrease harvest efficiency, and reduce profitability. To gain a better understanding of weed species likely to evade control interventions in commercial chile pepper production, we surveyed commercial fields in the Rio Grande Valley of southern New Mexico just before harvests of green chile fruits. Surveys were conducted in 2022 and 2023. Thirty-four fields were surveyed in 2022. Thirty-three fields were surveyed in 2023. For each weed species identified, we determined percentage of surveyed fields in which the species was present (frequency of occurrence), percentage of plants taller than the crop canopy, and percentage of plants with mature seeds. Results indicated twenty-eight weed

species occurred in commercial chile pepper fields at the time of green chile harvest. The five most frequent broadleaf weed species included spurred anoda (Anoda cristata, 80% of fields), Palmer amaranth (Amaranthus palmeri, 72% of fields), morningglory species (*Ipomoea* spp., 55% of fields), common purslane (Portulaca oleracea, 45% of fields), and Wright groundcherry (Physalis acutifolia, 36% of surveyed fields). For spurred anoda, Palmer amaranth, morningglory and Wright groundcherry, 40 to 72% of plants were taller than crop canopies, suggesting these species interfere with harvest operations. However, for these species, less than 20% of plants reached reproductive maturity, suggesting deposits to spurred anoda, Palmer amaranth, morningglory, and Wright groundcherry seedbanks can be prevented by control interventions implemented shortly before, or during, harvest. Accordingly, this survey informs future research for improved weed management in New Mexico chile pepper production.

Development of Non-synthetic Herbicide Application Programs for Weed Management in Perennial Crops. Clebson Gomes Goncalves*; University of California, UC Cooperative Extension, Lakeport, CA (074)

Non-synthetic (organic herbicides) are available to control weeds in conventional and organic perennial crop systems. However, the viability, practicality, and efficiency of organic herbicides are poorly understood. Field trials were conducted on one organic and one conventional walnut orchard to examine the efficacy of alternative organic herbicide application programs. Treatments included Weed Pharm (Acetic acid), Suppress (Caprylic acid + Capric acid), and AXXE (Ammonium nonanoate) applied at single, two, or three sequential applications. In addition, at the conventional walnut orchard site, three non-selective herbicides (Roundup (Glyphosate), Rely 280 (Glufosinate), and Scythe (Pelargonic Acid)) were included as a standard treatment. The results showed that organic herbicides just burn back the top area where the herbicide gets in contact. Weeds such as Italian ryegrass (Lolium multiflorum), field bindweed (Convolvulus arvensis), and prostrate knotweed (Polygonum aviculare) have the ability to recover very quickly, with the acceptable threshold control lasting only one or two weeks. The results have shown a slight or no separation between the tested non-synthetic herbicides, and large weeds or perennial weeds are the most challenging to control. These herbicides are more effective on small and medium-sized annual weeds due to their non-systemic activity. In general, Due to year-round weed infestation, our results have indicated that two to four applications of these herbicides are needed to provide glyphosate-like control and keep the orchard floor clear throughout the growing season. However, effectiveness of the herbicide depends on weed pressure, weed species, weed growth stage, and weather conditions at the time of application.

WATTS UP! Soil Applied Pulse Electric Field for Weed Control. Austin Frewert*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (075)

The Pacific Northwest currently leads tree seedling production in the United States, with tree nurseries predominantly relying on herbicide and chemical soil sterilant to control pests. These methods are becoming unsustainable due to heightened environmental regulations and rising costs. This research explores Pulse Electric Field (PEF) as an alternative. This method directs pulses of electrical energy through soil to inactivate pests. Increased inactivation is expected at higher energy intensity, however optimal intensities have not been determined for important weed

species. Dose-response studies were conducted to determine the energy required to inactivate Cyperus esculentus (CYPES) tubers and *Digitaria sanguinalis* (DIGSA) seeds. Propagules were soaked for 24 hours, and planted in 10 cm^2 containers filled with sterilized silt-loam soil. Treatments ranging from 15 to 480 J cm^{-3} of soil were applied to the containers at two field strengths: 50 or 250 V mm^{-1}. Plant emergence, height, and dry weight were recorded after destructive harvest at 28 days. Nonlinear regression was used to determine the effective dose required to reduce growth by 95% (ED_{95}). Regardless of field strength, the ED_{95} of CYPES shoots and roots was 98 J cm^{-3} and 108 J cm^{-3}, respectively. The 250 V mm^{-1} was more effective at reducing DIGSA shoot and root growth with an ED_{95} of 80 and 67 J cm^{-3}, respectively. These energy values were 2.2 times lower than the energy needed at 50 V mm^{-1}. Ongoing studies will examine how pulse duration, frequency, and field strength interaction affect important tree nursery weeds, pathogens, and nematodes.

Reducing Plastic Dependence in Horticulture: Hydromulching in Strawberry. Andres Torres Moya*, Greta Gramig, Deirdre Prischmann-Voldseth; North Dakota State University, Fargo, ND (076)

Plasticulture predominates in strawberry production. However, non-biodegradable polymers pose environmental risks and their use in organic agriculture is controversial. We assessed biodegradable cellulose-based hydromulches (CBHM) as polyethylene (PE) mulch substitutes in strawberry. CBHMs, made of shredded newsprint, water, and 6% dry weight (DW) guar gum, were applied to raised beds. CBHM treatment combinations of color (black or white) and rate (low: 5,800 or high: 8,700 kg DW ha^{-1}) were tested against commercial paper mulch (PAP), PE film, and weedy/weed-free checks at Absaraka (sandy soil, purslane-dominated) and Fargo (clay soil, Venice mallow-dominated). Weed density was assessed (06/27/23 and 08/08/23 at Absaraka, 07/17/23 and 08/18/2023 at Fargo). Weed biomass was measured in August. Strawberry fruit yield was quantified. Weed density for high-rate CBHMs did not vary from PE at Fargo during both samplings. At Absaraka, all CBHMs had greater weed densities compared to PE and PAP, but less than the weedy check; low CBHM rates, with 34.78 and 39.62 plants m^{-2}, performed poorly compared to high rates (3.70 and 17.43 weeds m^{-2}). Absaraka high rate CBHMs yielded greater (272.33 and 215.04 g $plant^{-1}$) than PE (143.74 g $plant^{-1}$). Lower rates (167.86 and 140.50 g $plant^{-1}$) did not differ from PE yield. At Fargo, white CBHM high rate out-yielded PE (286.55 vs. 253.35 g $plant^{-1}$), whereas yields for lower rates (222.64 and 161.76 g $plant^{-1}$) and black CBHM high-rate (211.73 g $plant^{-1}$) did not differ from PE. CBHMs can replace PE mulch with higher rates, controlling weeds while maintaining or enhancing strawberry yields.

Hydromulches Enhance Weed Management and Crop Yield in Organic Onion Production. Waqas Ahmad*[1], Sharon Weyers[2], Benjamin Weiss[3], Lisa Wasko DeVetter[3], Andrew Durado[4], Dilpreet Bajwa[4], Suzette P. Galinato[5], Alice Formiga[6], Greta Gramig[1]; [1]North Dakota State University, Fargo, ND, [2]USDA, ARS, Morris, MN, [3]Washington State University - NWREC, Mount Vernon, WA, [4]Montana State University, Mozeman, MT, [5]Washington State University-Pullman, Pullman, WA, [6]Oregon State University, Corvallis, OR (077)

Weed competition is a great challenge in organic onion production. Widely-used polyethylene (PE) film mulches effectively suppress weeds but contribute to environmental pollution as non-

biodegradable plastics. This study aimed to develop cellulose-based biodegradable hydromulches (HMs) as sustainable alternatives for weed control and yield protection in organic onion. HMs made of shredded newsprint, water, and two tackifiers (guar gum [GG] or camelina meal [CM], both at 3% and 6%) were applied using gasoline-powered pump at 5,765 kg dry matter ha^{-1}. HMs were evaluated against PE and weedy/weed-free checks (WC/WFC) at Absaraka and Fargo, ND. Weed density was evaluated at peak weed emergence (PWE) and peak weed vegetative growth (PWVG), with weed biomass measured at PWVG. Mulch deterioration and onion yield were quantified end-season. PE had zero weeds at both sites. At PWE, GG (3% and 6%) outperformed CM (3% and 6%) and WC (7 and 22 vs. 89, 152, and 314 plants m^{-2}) at Absaraka. In Fargo, HMs showed similar weed control efficacy, differing from WC. At PWVG, similar patterns of weed control efficacy were observed among treatments. GG (6%) had less weed biomass than WC (120 vs. 749 g $plant^{-1}$). PE and GG showed similar mulch deterioration (both 0%) at Fargo. Among mulches, Onion yield was highest in PE and 6% GG at Absaraka. In Fargo, onion yield was similar for GG (3% and 6%) and PE (36958, 38133, and 58808 kg ha^{-1}, respectively). Overall, HM with 6% GG can be an effective alternative to PE for organic onion production.

Evaluating Nostoc Control with Herbicides in Nursery Gravel Pads. David R. King*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (078)

A USDA survey conducted in 2006 found that there were over 2,000 nursery and greenhouse operations in Oregon. The crop value for these operations was over 1 billion dollars, making it the largest agricultural commodity for the state. Unlike other crops that are grown in fields, many nurseries and greenhouses are located on gravel pads using planter pots for propagation. A big issue facing greenhouse and nursery operations is the growth of nostoc on gravel pads and ground cover fabric. Nostoc is a species of cyanobacterium in the family Nostocaceae. When moist, nostoc can be extremely slippery, which can create serious slipping hazards for agricultural workers. The objective of this study was to evaluate Nostoc control using several different herbicides. The study was conducted in a commercial nursery with a high infestation of nostoc located near Boring, OR. Comparisons were made between treatments containing ammonium nonanoate, glufosinate, and sodium carbonate peroxyhydrate applied twice and a single application of copper hydroxide, indaziflam, potassium salts of fatty acids, and pelargonic acid. Nostoc control ratings were taken every 5 to 7 days up to 35 days after treatment. A single application of copper hydroxide controlled 60% of nostoc five days after treatment, and the control level increased to 80% for the study. The glufosinate effect on nostoc was noticed at 8 DAT (~ 30), rising to 85% at 14 DAT and for the remainder of the study. No other treatments controlled nostoc adequately in this study. Copper hydroxide and glufosinate can be used as effective options to control nostoc in nurseries.

Effect of Hill-drop Seeding on Snap Bean Yield and Potential of In-row Cultivation. Ed Peachey*; Oregon State University, Corvallis, OR (079)

In-row cultivation opportunities are limited in snap beans. Hill-drop seeding is used in cotton, buckwheat, other crops to improve emergence in crusted soil and may provide opportunity in snap beans for in-row cultivation with robotic weeders. The objectives of this project were to measure yield response of snap beans to hill-drop seeding. Snap bean seeds were seeded at two sites at 3, 6 or 9 seeds per 30 cm of row in 'hills' or uniformly within the seed row with a hand push belt planter.

All plots were cultivated with a robotic weeder one time when the first trifoliate was fully expanded. Snap beans were hand-harvested from 1.8 m of row and pods graded. In-row cultivation improved weed control early in the season and did not sacrifice yield, even when snap beans were hill-drop seeded at only 3 seeds per 30 cm of row. Total weed density at harvest, however, did not differ between hill-drop and uniformly seeded plots. Common lambsquarters density at harvest was reduced by 40% with in-row cultivation, but pigweed and common purslane densities were unaffected. Seeding density should be reevaluated in both hill-drop and uniformly seeded snap beans across commonly grown varieties. Cultivation speed with the robotic weeder was slow, at approximately 1.8 km hr-1, and would be an impediment to adoption.

Can Paper Mulch Replace Plastic Mulch for Floral Hemp Production? Brock C. Schulz*, Harlene M. Hatterman-Valenti, Collin Auwater; North Dakota State University, Fargo, ND (080)

A two-year study investigated the impact of various raised bed mulching sheets employed for weed control, including black plastic, white plastic, red plastic, and organic biodegradable paper, on growth and floral yield of field-grown hemp. Four cultivars were utilized including QuickSpectrum, Bubbatonic, Cherry Wine, and Sour Space Candy within a split-plot experimental design with mulching treatment as the whole plot factor and cultivar as the split-plot factor with four replicates. Conventional high-value crop production in irrigated raised beds typically involves the use of black polyethylene mulch in northern states, though variations in the color of plastic mulching, like white and red, have also been evaluated in raised bed systems for other crops. In this study, the traditional plastic options were compared with an environmentally friendly alternative OMRI certified biodegradable paper. Assessment of weed control and hemp growth parameters, namely height, weight, floral dry weight, and total dry weight of the above-ground portion suggest that, under the growing conditions in Cass County, ND, none of the mulches significantly influenced the measured parameters. This study highlights the need for further research evaluating potential limitations of paper mulch as a sustainable weed preventative and soil water conservative measure in raised bed production systems for transplanted floral hemp.

Halosulfuron and Imazosulfuron Effects on Yellow Nutsedge Plants Exceeding Sizes Listed on Labels. Brian Schutte*; New Mexico State University, Las Cruces, NM (081)

Herbicides applied to weeds that exceed sizes on labels may be sublethal doses that promote growth or reproduction by targeted weeds. This study aimed to determine the effects of imazosulfuron and halosulfuron on yellow nutsedge (Cyperus esculentus) plants larger than upper size limits for control on product labels. To address this objective, a field study was conducted at a university research farm in southern New Mexico in 2022 and repeated in 2023. Experimental units were yellow nutsedge plants grown in soil within polyvinyl chloride pipes (1 tuber $pipe^{-1}$). Experimental treatments were factorial combinations of plant size and herbicide. Plant size treatments included plants smaller than sizes on labels ("small", 7-cm height) and plants larger than sizes on labels ("large", 26-cm height). Herbicide treatments were high and low rates of halosulfuron (26 g ha^{-1}, 52 g ha^{-1}), imazosulfuron (168 g ha^{-1}, 336 g ha^{-1}), glyphosate (794 g ha^{-1}, 2395 g ha^{-1}), and non-treated control. Small plant and glyphosate treatments were positive controls. Herbicide solutions included label-recommended adjuvants. At 42 d after treatment (DAT), yellow nutsedge plants were recovered, dried, and weighed; and tubers were counted and assessed for

viability. Results indicated all herbicides equally reduced dry weight and tuber viability of small plants. Small plants treated with a herbicide had 0.4 ± SE 0.78 viable tubers plant^{-1} at 42 DAT; whereas small plants not treated with a herbicide had 10.4 ± SE 3.50 viable tubers plant^{-1}. For large plants, dry weight and tuber viability were similar between non-treated plants and plants treated with imazosulfuron at 168 g ha^{-1}. Imazosulfuron at 336 g ha^{-1}, halosulfuron (26 g ha^{-1}, 52 g ha^{-1}), and glyphosate (794 g ha^{-1}, 2395 g ha^{-1}) reduced dry weight and tuber viability of large plants. Maximum reductions in tuber viability were caused by halosulfuron at 52 g ha^{-1}. Large plants treated with halosulfuron at 52 g ha^{-1} had 1.3 ± SE 0.86 viable tubers plant^{-1} at 42 DAT, whereas large plants not treated with a herbicide had 19.4 ± SE 4.41 viable tubers plant^{-1}. These results suggest applications of imazosulfuron (336 g ha^{-1}) and halosulfuron (26 g ha^{-1}, 52 g ha^{-1}) to yellow nutsedge plants with 26-cm height a size that exceeds thresholds for control on product labels are not sublethal doses that promote growth or reproduction in this weed species.

Management of Herbicide-Resistant Palmer Amaranth in Chipping Potato. Nevin Lawrence*; University of Nebraska, Scottsbluff, NE (082)

Group 2, 3, 5, 14, and 15 herbicides are commonly used within potato production in tank mixes to provide broad-spectrum and season-long weed control. In Nebraska, the most common weed control program in chipping potato is a tank mix of flumioxazin, metribuzin, and s-metolachlor applied at hilling. Palmer amaranth resistant to group 2 and 9 herbicides is widespread across NE, and group 5, 14, and 27-resistant populations are also present. Several potato growers have struggled with managing Palmer amaranth in the past several years, and in response to these challenges a weed control trial was conducted in Scottsbluff, NE in 2021, 2022, and 2023. The purpose of these trials was to identify the best weed control program for Palmer amaranth management based upon which herbicide-resistant biotypes are present in the field. Treatments included a non-treated check; an industry standard check of flumioxazin, metribuzin, and s-metolachlor applied at hilling; metribuzin, s-metolachlor, and pendimethalin applied at hilling to simulate group 2 and 14 resistance; flumioxazin, s-metolachlor, and pendimethalin applied at hilling to simulate group 2 and 5 resistance; and various combinations of s-metolachlor, dimethenamid-p, and pendimethalin applied PRE, at hilling, and 4 w after hilling. In 2022, high temperatures, no precipitation, and the failure of an irrigation pump for the six weeks following planting led to poor incorporation of soil active herbicides. In 2021 and 2023; flumioxazin, metribuzin, and s-metolachlor; metribuzin, s-metolachlor, and pendimethalin; and flumioxazin, s-metolachlor, and pendimethalin applied at hilling had the lowest Palmer amaranth densities. The next best treatment was dimethenamid-P plus pendimethalin applied PRE, followed by s-metolachlor plus pendimethalin applied at hilling, followed by s-metolachlor applied 4 w after hilling. Effective season-long Palmer amaranth control within chipping potato is possible even with populations resistance to group 2, 5, and 14 herbicides.

Weed Control and Nitrogen Rate Trial on Native Spearmint. Rui Liu*[1], Troy Peters[1], Ruijun Qin[2]; [1]Washington State University, Prosser, WA, [2]Oregon State University, Hermiston, OR (083)

Washington State is one of the major native spearmint-producing states in the US. A field study was conducted in 2023 on a double-cut native spearmint field at Washington State University Irrigated Agricultural Research and Extension Center (WSU-IAREC) in Prosser, WA. The

objectives of the study were: 1) to evaluate the efficacy of the herbicide tiafenacil for weed control; 2) to investigate different nitrogen application rates and timings on spearmint yield and oil production. Tiafenacil at 50 and 100 g ai/ha were applied at spearmint dormant stage, in comparison to paraquat at 560 g ai/ha, and saflufenacil +pyroxasulfon at 101 g ai/ha. Visual control (%) of weeds and mint injury were recorded 7 days after application and 14, 21, and 28 days after mint green-up. In a separate part of the field, six nitrogen application rates (0, 56, 112, 168, 224, and 280 kg/ha and three application timings (all N applied in spring, ½ N applied inspiring + ½ N applied after 1st cutting, 2/3 N applied in the spring + 1/3 N applied after 1st cutting) were evaluated. Rattail fescue, prickly lettuce, dandelion, western salsify, and flixweed were the dominant weed species present in the field. All herbicides provided moderate to excellent (70-100%) control on prickly lettuce and flixweed at 14, 21, and 28 days after spearmint green-up. Tiafenacil at 100 g ai/ha caused 4 to 7% injury, which resulted in less mint hay yield. However, oil production did not show a significant difference among herbicide treatments. Results also indicated that higher mint oil were produced when high nitrogen was applied all in spring (Timing1), or 2/3 of N applied in the spring, and 1/3 applied after first cutting (Timing 3). Mint leaf greenness decreased with a lower N rate, especially during the late growing stage, regardless of the application timing.

WSWS Project 3. Weeds of Agronomic Crops

Relating Herbicide Residue Level to Sugarbeet Stand and Growth Reduction. Adam Kennedy*[1], Albert T. Adjesiwor[1], Clarke Alder[2]; [1]University of Idaho, Kimberly, ID, [2]Amalgamated Sugar, Boise, ID (022)

One common recommendation given to growers who suspect herbicide carryover to sugarbeet (*Beta vulgaris*) is to conduct laboratory tests to assess herbicide residue levels in the soil. While this is often a good practice, there are currently no guidelines on how these laboratory test results relate to sugarbeet damage or yield loss. Greenhouse studies were conducted in 2022 and 2023 to assess the relationship between soil residue levels of seven herbicides (flumioxazin, imazamox, mesotrione, metribuzin, rimsulfuron, and terbacil) and sugarbeet stand and growth reduction. At levels below the limit of detection, rimsulfuron reduced sugarbeet stand density by more than 50% and biomass by 25%. Sugarbeet stand density and biomass were reduced by about 40% and 25%, respectively, at metribuzin residue levels below the limit of detection. Similarly, flumioxazin reduced stand density and biomass by 50% at residue levels below the limit of detection. Stand density and biomass reduction due to mesotrione exceeded 50% even at residue levels below the limit of detection. Imazamox and terbacil caused minimal sugarbeet stand and biomass reduction at residue levels below the limit of detection. These results demonstrate that laboratory analysis of herbicide residue levels in the soil must be accompanied by a bioassay to determine the potential crop damage from herbicide carryover.

Pre-emergence Herbicide Efficacy as Influenced by Delayed Incorporation. Chandra L. Montgomery*[1], Albert T. Adjesiwor[2]; [1]University of Idaho, Moscow, ID, [2]University of Idaho, Kimberly, ID (023)

Pre-emergence herbicides have increasingly been used in herbicide programs to provide overlapping weed control and combat troublesome weeds in cropping systems. In most small grain production systems, growers often rely on precipitation for incorporating these soil-applied herbicides. Many of these pre-emergence herbicides require certain amounts of water after application to become activated. A field study was conducted in 2023 at the University of Idaho Research and Extension Center at Kimberly, Idaho to quantify the minimum amount of soil moisture required to incorporate metribuzin, pyroxasulfone, pendimethalin, and s-metolachlor for kochia (*Bassia scoparia*) and Italian ryegrass (*Lolium multiflorum*) control. Due to an extremely dry soil profile and high soil temperatures, not even the highest irrigation amount (2.54 cm of water) was enough to successfully incorporate any of the herbicides. Beginning at 3 weeks after herbicide application, research plots were uniformly overhead irrigated weekly with 2.54 cm of water at each irrigation event for 4 weeks to evaluate how delayed incorporation influenced the efficacy of metribuzin, pyroxasulfone, pendimethalin, and s-metolachlor. Metribuzin, pyroxasulfone, s-metolachlor and pendimethalin provided 8, 43, 51, and 72% of Italian ryegrass control, respectively. Kochia control was 6, 69, 76, and 95% in the s-metolachlor, pendimethalin, pyroxasulfone, and metribuzin treatments, respectively. This study will be repeated in 2024 and 2025 using a modified methodology to better characterize the activation moisture requirements of these herbicides.

Quizalofop Efficacy for Feral Rye Control in CoAXium Wheat Production Systems in Oregon. Victor Ribeiro*[1], Carol Mallory-Smith[1], Jennifer Gourlie[2], Judit Barroso[3]; [1]Oregon State University, Corvallis, OR, [2]Oregon State University, Pendleton, OR, [3]Oregon State University, Adams, OR (024)

Winter annual grasses are difficult to control in wheat. Quizalofop-resistant (CoAXium) wheat allows growers to use quizalofop (Aggressor AX) for grass control. The objective of this study was to evaluate the efficacy of quizalofop for the control of feral rye (*Secale cereale* L.) and for crop injury in a quizalofop-resistant soft white winter wheat variety in Oregon. Quizalofop efficacy was also assessed on naturally occurring populations of downy brome *(Bromus tectorum* L.) and jointed goatgrass (*Aegilops cylindrica* Host). Field experiments were conducted over two winter wheat growing seasons in 2021-2022 and 2022-2023 near Adams, OR, using a randomized complete block design with four replications. Herbicide treatments included pyroxsasulfone (119 g ai ha^{-1}) and pyroxsasulfone + carfentrazone-ethyl (123 + 9 g ai ha^{-1}) applied PRE, and quizalofop (77 and 92 g ai ha^{-1}) applied POST in the spring. Quizalofop treatments were applied with 32% urea ammonium sulfate (5 L ha^{-1}) and MSO (1% v/v), using four different spray volumes (94, 140, 187, and 281 L ha^{-1}). Crop injury was assessed at 14 and 21 days after POST treatments. Visual weed control was assessed nine weeks after POST treatments. Weed biomass was collected near the end of the season and crop yield was assessed at harvest. Spring-applied quizalofop caused no injury to winter wheat. Quizalofop treatments provided effective control of feral rye (=95%), downy brome (=87%), and jointed goatgrass (99%) regardless of rate, adjuvant, and spray volume tested. Adoption of quizalofop-resistant wheat technology can help Pacific Northwest wheat growers selectively control winter annual grasses.

Alternative Herbicides to Control Glyphosate-Resistant *Erigeron* spp. Jennifer Gourlie*[1], Fernando H. Oreja[2], Judit Barroso[2]; [1]Oregon State University, Pendleton, OR, [2]Oregon State University, Adams, OR (025)

Herbicide resistance is a concern among growers with wheat/fallow systems in the semi-arid region of Pacific Northwest. In an effort to assist these growers in controlling glyphosate-resistant *Erigeron* spp. populations, we conducted a greenhouse study to determine if those populations could be controlled with alternative herbicides. In this study, we tested seven populations using rates of 0X, 1X and 2X, replicated four times. Target weeds were horseweed (*Erigeron canadensis*) and hairy fleabane (*Erigeron bonariensis*). Studied treatments included glufosinate (Forfeit® 280) at 594 g ai ha^{-1}, halauxifen-methyl + florasulam (Quelex®) at 5.2 g ai ha^{-1} + 5.2 g ai ha^{-1} , clopyralid (Stinger®) at 131 g ai ha^{-1}, pyraflufen (Vida®) at 2 g ai ha^{-1}, and metribuzin (Metribuzin 75) at 315 g ai ha^{-1} as 1X for all these herbicides. Results for visual control with 1X showed, on average among the populations, 100% with Forfeit 280, 76% with Metribuzin 75, 73% with Vida, and lower controls with Quelex (61%) and Stinger (49%). Results for fresh weight followed a similar trend compared to the visual control. For the 1X treatment, control averaged among populations was 89% with Forfeit 280, 88% with Metribuzin 75, 83% with Vida, and lower for Quelex 27% and Stinger (17%). This study showed glufosinate, metribuzin, and pyraflufen as adequate alternative herbicides to control glyphosate-resistant populations of marestail and hairy fleabane.

Integration of Fall-Planted Cereal Cover Crops and Herbicides for Weed Control in Dry Bean. Prayusha Bhattarai*[1], Albert T. Adjesiwor[2], Olga S. Walsh[3]; [1]University of Idaho, Twin Falls, ID, [2]University of Idaho, Kimberly, ID, [3]University of Idaho, Parma, ID (026)

Herbicide resistance is a growing concern in dry bean (*Phaseolus vulgaris*) production systems due to limited effective herbicide options and the highly susceptible nature of the crop to weed interference. Field experiments were conducted in Parma and Kimberly, Idaho to determine the weed suppression ability of fall-planted cover crops in dry beans based on the termination practice (chemical termination vs. haying) and herbicide programs. The experiment was laid out as a split-plot randomized complete block with four replicates. Treatments included three different cereal cover crops (barley, *Hordeum vulgare*; triticale, *Triticosecale rimpaui*; and wheat, *Triticum aestivum*) and no cover crop. Cereal cover crops were either terminated chemically with glyphosate or harvested for forage. There were three preemergence herbicides, one post-emergence, and a nontreated check. Haying treatments reduced dry bean stand density by 39% in Parma but had no significant effect in Kimberly. Cover crops reduced weed biomass by 52 to 79% in Parma, while herbicides reduced weed biomass at both locations. Herbicide treatments reduced weed density by up to 72% in Parma and 60% in Kimberly when compared to the nontreated checks. Dry bean seed yield was reduced by 23 to 30% in Parma and 40 to 64% in Kimberly in the nontreated check when compared to herbicide treatments. This study showed the potential of integrating cover crops and herbicides for effective weed management in dry beans.

***Echinochloa* Complex Differential Response to Florpyrauxifen-benzyl in California.** Deniz Inci*, Kassim Al-Khatib; University of California, Davis, Davis, CA (027)

Preliminary research suggests watergrasses, *Echinochloa* complex, show differential responses to florpyrauxifen-benzyl. Early watergrass, barnyardgrass, and late watergrass are the major *Echinochloa* species that are present in California water-seeded rice. This research aimed to study *Echinochloa* complex biotypes' differential response to florpyrauxifen-benzyl. A dose-response study was conducted in the greenhouse in 2022 and 2023. Florpyrauxifen-benzyl was applied at 0, 5, 10, 20, 40, 80, and 160 g ai/ha use rates to nine early watergrass, ten barnyardgrass, and seven late watergrass populations. Methylated seed oil at 1% v/v was added to all treatments. The study was arranged in a randomized complete block design with four replicates and was repeated twice. Visual injuries were rated at 0, 7, 14, 21, and 28 days after treatments (DAT) using a scale where 0 means no injury and 100 means plant death. At 28 DAT, studies were terminated, plants were harvested, and dry weight was measured. Data were analyzed using analysis of variance and nonlinear regression analysis to determine florpyrauxifen-benzyl rate required to cause 50% dry weight reduction, using sigmoidal logistic three parameters. The florpyrauxifen-benzyl rate required to control watergrass populations was found to be 300 g ai/ha for late watergrass, 220 g ai/ha for early watergrass, and 120 g ai/ha for barnyardgrass. The field rate for florpyrauxifen-benzyl is 40 g ai/ha, significantly lower than the rates required to control the tested populations. The research suggests that some *Echinochloa* populations found in California water-seeded rice systems may easily escape from florpyrauxifen-benzyl applications.

Confirmation of Glyphosate Resistance in *Erigeron spp.* in Oregon. Fernando H. Oreja*[1], Jennifer Gourlie[2], Judit Barroso[1]; [1]Oregon State University, Adams, OR, [2]Oregon State University, Pendleton, OR (028)

The reliance on herbicides in no-till systems may lead to the repeated use of specific herbicides, contributing to the selection pressure that favors the development of resistant weed populations. Two wheat growers from Wasco and Umatilla Counties, in Oregon, reported poor control of *Erigeron* spp. plants following glyphosate applications in fallow fields and inquired about resistance screening. Seeds from three populations, two suspected of being resistant and one susceptible to glyphosate, were studied. Plants, with diameters ranging from 3 to 4 cm, were treated with glyphosate (Gly Star 5 Extra) at doses of 0 (untreated check), 852 (1X), 1705 (2X), 3410 (4X), and 6819 (8X) g ai ha^{-1}, with four replicates per treatment. Applications were carried out using a spray chamber equipped with a single nozzle (Even Flat Spray TP8002E tip, Teejet Technologies), set to deliver 140 L ha^{-1}. At 21 days after treatment, surviving plants were evaluated for visual control, harvested, and weighed to assess biomass accumulation. Three-parameter log-logistic models were applied to the relative dry weight data (% of untreated control) to estimate the rates required to achieve a 50% reduction in growth (RG50) and resistance ratios (RR). The susceptible *Erigeron* spp. population exhibited a RG50 of 328.7 g ha^{-1}. Both populations suspected of being resistant exhibited resistance to glyphosate. The population from Wasco had an RG50 = 3339 g ha^{-1} and an RR = 10.2. The Umatilla population demonstrated an RG50 = 38140 g ha^{-1} and a RR = 116.0. More studies are evaluating *Erigeron* spp. responses to alternate herbicides to determine the best options to control these populations.

Tolpyralate and Bromoxynil Efficacy on Green Foxtail in Small Grains. Hayden J. Lee*[1], Kirk A. Howatt[1], Joseph Mettler[1], Ryan M. Humann[2]; [1]North Dakota State University, Fargo, ND, [2]Corteva Agriscience, Fargo, ND (029)

In small grains, post emergence grass weed control is limited to ACCase- (Group 1) and ALS- (Group 2) inhibiting herbicides. Green foxtail (*Setaria viridus*) has developed resistance to these sites of action. Tolpyralate (Group 27) mixed with bromoxynil (Group 6) has shown activity on foxtails but is primarily used for broadleaf control. To further investigate grass activity, field experiments in 2023 were conducted at three locations to determine the effect of application timing (1-leaf, 3-leaf, and tillering) on foxtail control. Treatments were arranged in a randomized complete block design with four replicates, comparing tolpyralate and bromoxynil to industry standards. Visual evaluations for foxtail control and wheat response were performed at 7, 14, and 21 days after treatment (DAT). Foxtail biomass and wheat grain yield were measured at the end of the season. Green foxtail at Prosper showed resistance to Group 1 herbicides, observed as less than 3% control (21 DAT) when sprayed with an ACCase herbicide. At the same location greater than 91% foxtail control (21 DAT) was observed with tolpyralate and bromoxynil. Application timing did not significantly affect visible control with tolpyralate and bromoxynil. However, the biomass accumulation following the 1-leaf timing was significantly greater than the other timings. This was consistent at all locations and likely the effect of new foxtail flushes throughout the growing season. Spraying tolpyralate and bromoxynil at the 3-leaf timing provided at least 90% control of green foxtail while avoiding post application emergence following the 1-leaf timing.

Effect of Relative Humidity on Glufosinate Efficacy in Kochia and Common Lambsquarters Populations. Het Samir Desai*[1], Lovreet S. Shergill[2], Fabian Menalled[1]; [1]Montana State University, Bozeman, MT, [2]Montana State University, Huntley, MT (030)

Relative humidity of =60% significantly enhances glufosinate efficacy. In the Northern Great Plains, where relative humidity often ranges from 25% to 35% during summer, sub-optimal weed management following glufosinate application is a recurrent issue. However, higher relative humidity (60%-80%) during early morning hours could aid in increasing overall glufosinate efficacy. Therefore, this study aims to address two important research questions: (1) How long do *Bassia scoparia* A. J. Scott and *Chenopodium album* L. require =60% relative humidity after glufosinate application for effective control, and (2) Is there a merit in applying glufosinate during early morning hours? A greenhouse study was conducted in a split-split plot design with three replications and two known glufosinate-susceptible *B. scoparia* and *C. album* populations. Seven relative humidity levels, two nozzles (e.g., TeeJet-XR8002VS and TTJ60-110025), and two populations of each weed species were assigned to the mainplots, subplots, and subsubplots, respectively. Glufosinate-treated plants (0.6 kg ai ha^{-1} + 20 g L^{-1} ammonium sulfate) were exposed to elevated humidity (=60%) for 1 h, 2 h, 4 h, 6 h, 8 h, and 21 d, and ambient humidity (25-35%) for 21 d. While glufosinate-treated *B. scoparia* exhibited 15-19% survival when kept in the ambient humidity, 0% survival was observed in =1 h of elevated humidity. *Chenopodium album* was completely controlled when plants were kept in elevated humidity for 21 d, whereas 60-100% survival was observed in all other humidity treatments. Data suggest that early morning application of glufosinate could effectively manage *B. scoparia* but not *C. album*.

Effects of Adjuvants on Canola Desiccation with Diquat. Jim T. Daniel*[1], Kirk A. Howatt[2]; [1]Daniel Ag Consulting, Keenesburg, CO, [2]North Dakota State University, Fargo, ND (031)

Abstract not Available

Wild Oat Resistance in North Dakota. Joseph Mettler*, Kirk A. Howatt; North Dakota State University, Fargo, ND (032)

Wild oat (*Avena fatua*) has been a problematic weed in wheat (*Triticum aestivum* L.) fields for decades. Since 2019, 61% of wild oat submissions from fields of concern have exhibited resistance to both ACCase (Group 1)- and ALS-inhibiting (Group 2) herbicides. Only 8% of submissions were completely susceptible. To capture the level of severity in 2022, a statewide sampling of wild oat was conducted. In a greenhouse in Fargo, ND, 98 collections were compared to a known susceptible population for resistance to various Group 1 and Group 2 herbicides. Herbicide treatments were applied to 2- to 3-leaf wild oat at 94 L ha^{-1} with a Flat Fan TeeJet 8001EVS nozzle in a spray chamber. Evaluations for percent visible injury were obtained 21 days after application and standardized to the susceptible population. Individual collections were resistant to Group 1, Group 2 or both sites of action at an incidence of 16, 6, and 12%, respectively. Singular herbicide resistance was expressed in 6% of the collections. The highest levels of herbicide resistance occurred with flucarbazone at 26% of the collections, quizalofop-p-ethyl at 29% and fenxoxaprop-p-ethyl at 42%. Resistance to clethodim was expressed in less than 5% of the samples collected. Of the wild oat collections that were screened, 36% were susceptible to all herbicides tested, without even slight levels of resistance indicated. This research shows that the incidence of Group 1 and/or Group 2 resistant wild oat is much lower state-wide than what the results from the wild oat submissions suggest.

In-Vitro Evaluation of Sorgoleone for Monocot Weed Growth Inhibition. Devanshi H. Desai*[1], Paul Nugent[1], Clint M. Mattox[2], Joan Campbell[3], Scott R. Baerson[4], Timothy Seipel[1], Wesley Everman[5], Lovreet S. Shergill[6]; [1]Montana State University, Bozeman, MT, [2]USDA-ARS, Corvallis, OR, [3]University of Idaho, Moscow, ID, [4]USDA-ARS, Oxofrd, MS, [5]North Carolina State University, Raleigh, NC, [6]Montana State University, Huntley, MT (033)

The evolution of herbicide resistance poses a significant threat to Great Plains cropping systems in the United States. Due to this phenomenon, the efficacy of existing herbicides greatly decreased, causing considerable yield and revenue losses that sporadically affect farmers' socioeconomic welfare in this region. Sorgoleone, a naturally occurring compound derived from *Sorghum bicolor* (L.) Moench. root exudates exhibit herbicidal properties against certain weed species. An in-vitro study aimed at evaluating the efficacy of sorgoleone on monocot weeds was conducted in a randomized complete block design with four replications, seven sorgoleone doses (0, 30, 50, 100, 150, 200, and 300 mg/L), and five weed species. Results indicate that increasing sorgoleone doses significantly reduced plumule length for all tested species. Based on PR_{50} (i.e., sorgoleone dose required for 50% plumule inhibition), *Setaria viridis* (L.) Beauv. (26.3 mg/L) was highly sensitive to sorgoleone, followed by *Avena fatua* L. (37.7 mg/L). PR_{50} values for other weed species, including *Aegilops cylindrica* Host, *Bromus tectorum* L., and *Lolium persicum* Boiss. & Hoh. ranged from 91.7 to 661.8 mg/L. Additionally, machine learning and computer vision approaches

are being explored to measure plumule length accurately. The Computer Vision Annotation Tool (CVAT) software facilitated plumule length annotations, while computer vision models (YOLOv8) were utilized to detect plumules, employing transfer learning from networks pre-trained on COCO or ImageNet datasets. Pending field-level evaluation, this study suggests that sorgoleone could serve as a potential alternative for non-chemical sustainable weed management, showcasing the promising role of computer vision in streamlining data collection.

Fall Application of Residual Herbicides Reduces Weed Abundance in Spring-Planted Chickpeas. Akamjot S. Brar*[1], Qasim Khan[2], Fabian Menalled[1], Clint W. Beiermann[3], Zach Miller[4], Kent McVay[2], Lovreet S. Shergill[2]; [1]Montana State University, Bozeman, MT, [2]Montana State University, Huntley, MT, [3]University of Wyoming, Laramie, WY, [4]Montana State University, Corvallis, MT (034)

Pulses, including chickpeas (*Cicer arientinum* L.), offer expanded market opportunities and weed management options, but their slow germination and early growth make early-stage weed control crucial for successful establishment. Fall application of soil-active residual herbicides can aid in early-season weed suppression and improve the establishment of spring-planted chickpeas. Field experiments were conducted with randomized complete block design with 4 reps and 14 treatments at two sites, Southern Agriculture Research Center, Huntley, and Western Agriculture Research Center, Corvallis, Montana during 2022 and 2023 to evaluate crop safety and broadleaf weed control by fall-applied soil active herbicides followed by a POST application in chickpeas. Pyroxasulfone at 131 g/ha ae+ flumioxazin at 60.6 g/ha ae, dimethamid at 950 g/ha ae + pendimethalin at 1.68 kg/ha ae, and metribuzin at 420 g/ha ae provided 90-99% broadleaf weed control at both sites Kochia (*Bassia scoparia* L.), Common Lambsqaurters *(Chenopodium giganetum* L.) and Redroot pigweed (*Amaranthus retroflexus* L.). A single follow-up POST application of pyridate (700 g/ha ae) helped in ensuring season-long control by eliminating weeds that emerged late or escaped PRE. There was no visual injury of any herbicide and yield reductions in chickpeas, and a 90-100% increase in yield compared to untreated control was observed with best treatments. These herbicide programs can be used in integration with other weed management tactics in pulse crops for effective weed control.

Glyphosate & Glufosinate: Fate in California Almond Orchards. Rohith Vulchi*, Bradley D. Hanson; University of California, Davis, Davis, CA (035)

Glyphosate and glufosinate are commonly used for preharvest vegetation management in California almond orchards. Occasionally, kernel samples have total glufosinate at or near the European Union (EU) tolerance limits and research suggests this is likely driven by the primary metabolite, MPPA. Therefore, to understand the fate and transformation of glyphosate, glufosinate and their metabolites in the soil in an orchard environment, the two herbicides were applied as a tank mix in a micro-sprinkler irrigated orchard and an adjacent non-crop, unirrigated site. One set of treatments included monthly applications of the glyphosate and glufosinate tank-mix at either a full rate or a reduced rate from April through July. Soil samples were collected a week before harvest to evaluate herbicide fate in soil relative to different spring/summer application timings. Another set of treatments included a single application of the glyphosate and glufosinate tank-mixes in April with soil samples collected monthly until a week before harvest. Leaf and kernel

samples were collected to understand the correlating levels of parent compounds and metabolites to various spring/summer applications for both sets of treatments. Glyphosate and glufosinate residues in soil, leaf, and kernel samples were quantified in a commercial laboratory. Parent glufosinate was not detected in kernel samples directly harvest from the trees. MPPA detections were below the EU tolerance limits (range: 0.011 - 0.093 ppm) and unaffected by application timing. This indicates in orchards with no recent history of glufosinate use, MPPA concentrations in kernels would be similar for the applications made between April and July.

Palmer Amaranth (*Amaranthus palmeri*) and Waterhemp (*Amaranthus tuberculatus*): an Emerging Problem in Idaho and Oregon. Clarke Alder*[1], Albert T. Adjesiwor[2], Joel Felix[3]; [1]Amalgamated Sugar, Boise, ID, [2]University of Idaho, Kimberly, ID, [3]Oregon State University, Ontario, OR (036)

In late July 2023 both Palmer amaranth and Waterhemp were discovered in southern Idaho. In September 2023 Palmer amaranth was discovered in eastern Oregon. Four large populations of Palmer amaranth have been confirmed in agronomic crops such as potatoes, wheat, and beans. A single waterhemp population was confirmed in sugar beet. Palmer amaranth was also discovered along many roadways in southern Idaho indicating spread via trucks or farm equipment throughout the area. The waterhemp population was traced back to a local manure supplier who sourced feed from midwestern states. Twenty three samples were taken and tested from glyphosate resistance, 17 which were confirmed resistant. Additional herbicide screenings are taking place currently to determine any additional resistance contained within these populations.

Does Soil-applied Nitrogen Influence Weed Control and Soybean Yield? Jill Alms, David Vos, Eric Jones*; South Dakota State University, Brookings, SD (037)

Nitrogen fertilizer is applied to crops to increase vigor and yield. Nitrogen can also influence seed germination and susceptibility to herbicides. Field experiments were conducted in soybean to determine if soil-applied nitrogen fertilizer could increase weed germination, weed susceptibility to herbicides, and yield. Experiments were conducted in South Shore and Volga, South Dakota during the 2023 growing season. Redroot pigweed and waterhemp inhabited the South Shore and Volga locations, respectively. *S*-metolachlor and soil-applied nitrogen (0 to 56 kg ha^{-1}) were applied in factorially arrangement at planting. Weed germination increased with soil-applied nitrogen rates of 26 and 56 kg ha^{-1}, respectively. All other treatments (including nontreated and *S*-metolachlor) exhibited similar germination at each location, respectively. Glufosinate (655 g ai ha^{-1}) was applied when weeds were 15 cm in height at each location. Redroot pigweed control with glufosinate increased by approximately 10% with soil-applied nitrogen. Waterhemp control with glufosinate was similar with all tested soil-applied nitrogen rates. Yield increased with the application of *S*-metolachlor at South Shore, but the yield was largely not different at Volga. The results of this experiment provide evidence that soil-applied nitrogen can increase weed germination but the inclusion of *S*-metolachlor did not increase control. Results also suggest that soil-applied nitrogen can influence herbicide susceptibility but may be species dependent. While soil-applied nitrogen did not increase soybean yield, the implications of weed control could warrant application.

Evaluation of Stale Seedbed and Delayed Planting Date for Weed Management in Sugar Beet. Newman Benjamin Teye-doku*; University of Wyoming/Plant Science Department, Laramie, WY (038)

Herbicides and herbicide-resistant sugar beet varieties have been widely adopted in North America due to the economic benefits and simplicity of weed control. The frequent exposure of weeds to herbicides has selected for herbicide-resistant weed species to multiple herbicide sites of action in sugar beet producing regions. Weeds in sugar beet fields are currently known to exhibit resistance to glyphosate, ALS-inhibitors, and dicamba, as well as other herbicides. Widespread herbicide resistance requires an integrated weed management program that reduces reliance on herbicides. Field studies were conducted near Lingle, WY and Scottsbluff, NE in 2023 to evaluate the effectiveness of a stale seedbed approach to weed management in sugar beet. Treatments included four different sugar beet planting dates ranging from April 15 to May 31, and three preemergence (PRE) herbicide treatments (ethofumesate, EPTC, or no PRE). Results from Scottsbluff are not presented due to severe hail damage. PRE herbicide treatment had no significant effect on midseason weed biomass ($P = 0.238$) or sugar beet yield ($P = 0.882$). Mid-season weed biomass decreased as planting date was delayed ($P < 0.001$). Sugar beet root yield increased as planting date was delayed ($P = 0.004$), due to reduced weed biomass from later plantings. These results suggest that delaying planting date to effectively reduce weeds could be an effective strategy to manage early emerging weeds and reduce competition in the absence of effective postemergence herbicides.

Potential Of Soil and Plant Surfactants on the Efficacy of Some Pre-and-post Emergence Herbicides. Bianey A. Medina Garcia*[1], John Breen[2], Anil Shrestha[3]; [1]Caifornia State University Fresno, Fresno, CA, [2]Nutrien Ag Solutions, Biola, CA, [3]California State University, Fresno, CA (039)

Adjuvants are used to enhance the efficacy of (PRE) and (POST) herbicides. Foliar adjuvants help herbicides penetrate leaf cuticles of weeds and soil adjuvants can potentially help prolong the efficacy of PRE herbicides by increasing their absorption on soil particles. Methylated seed oil (MSO) and Ammonium Sulfate (AMS) are POST adjuvants that stimulate foliar penetration while; Infuse® is a soil-applied adjuvant that could help increase the effectiveness of PRE herbicides. However, these products need to be further tested on problematic weeds in California. Therefore, the objectives of these study were to evaluate: (1) the efficacy of a soil adjuvant on the effectiveness of PRE herbicides in a drip irrigated vineyard; (2) the efficacy of a soil adjuvant on the effectiveness of PRE herbicides on common lambsquarters (*Chenopodium album*) emergence; and (3) the efficacy of adjuvants with POST herbicides on hairy fleabane (*Erigeron bonariensis*) at different growth stages. A split-plot design was used in the vineyard, where the main plot was herbicide (®, Craze®, or Matrix®) and subplot was +/- Infuse®. While there were differences between the herbicide types, Infuse® had no effect on weed emergence. The results were similar for the common lambsquarters greenhouse pot study. In the hairy fleabane greenhouse study, Rely250® provided the best control of hairy fleabane regardless of adjuvants at both growth stages. Adjuvants had no effect on Roundup Powermax®. MSO-alone, in general, increased the efficacy of BAS851 and Treevix® at the rosette stage and of BAS850 at the bolting stage.

Wheat, Canola, and Pulse Tolerance to Pronamide. Joan Campbell*; University of Idaho, Moscow, ID (040)

Herbicide-resistant Italian ryegrass has in large part, driven the growth in spring canola acreage throughout high rainfall region of northern Idaho and eastern Washington. Because very few effective herbicide options are available to wheat and pulse crop growers, they have increasingly turned to Roundup Ready (RR) canola cultivars and glyphosate for the control of Italian ryegrass. Resistance to glyphosate has occurred in some southern U.S. states, California, and western Oregon from repeated use of glyphosate on RR crops or in orchards. Italian ryegrass resistance to glyphosate is not yet present in eastern Washington and northern Idaho, but sole reliance on glyphosate in canola threatens the effectiveness of this approach. Pronamide herbicide is effective at controlling Italian ryegrass in multiple high-value crops and turf. To test pronamide's suitability for the crop rotation of this region, two field sites (Moscow and Genessee, Idaho) were treated with pronamide at 1.25 and 2.5 pt/a applied in the fall and spring. Following the spring application, spring canola, pea, chickpea, and lentil were seeded. The experiments were arranged in randomized complete block with four replications. Plant visual injury and yield were measured. In both locations, winter wheat was seeded in the fall after harvest. Plant visual injury and yield was measured. The experiments were repeated at both locations. The first year, 2021, was the driest on record in almost half a century resulting in low spring crop yields. The extreme drought conditions likely slowed the breakdown of pronamide thus injuring subsequent winter wheat. Spring 2022 was wet and cold which resulted in low yields on some spring crops. The subsequent winter wheat crop grain yield in 2023 was moderately reduced from pronamide at the Genesee site and significantly reduced at the Moscow site. The variable results of winter wheat injury from pronamide suggest it may not be a good fit for winter wheat directly following spring rotational crops.

Rapidicil™, a New Preplant Burndown PPO-Herbicide from Valent U.S.A. Garrison J. Gundy*[1], Patrick A. Clay[2], John Pawlak[3], Jonathon Kohrt[4], Chad L. Smith[5], Eric J. Ott[6], Randall L. Landry[7]; [1]Valent U.S.A LLC, Mcpherson, KS, [2]Valent U.S.A. LLC, Fresno, CA, [3]Valent U.S.A. LLC, Spring Lake, MI, [4]Valent USA LLC, Noblesville, IN, [5]Valent U.S.A. LLC, Hallsville, MO, [6]Valent U.S.A. LLC, Greenfield, IN, [7]Valent U.S.A. LLC, Seymour, IL (041)

Rapidicil™ (epyrifenacil) is a novel, low-use rate PPO-inhibitor currently being developed by Valent USA LLC for preplant burndown uses in corn, canola, soybean, wheat, and non-crop areas/industrial vegetation management. *Rapidicil* demonstrates unique characteristics compared to other PPO's as it can be translocated via both the xylem and phloem for control of both broadleaf and grass weeds. *Rapidicil* in field and greenhouse trials conducted throughout the Midwest and Midsouth have shown excellent activity against difficult to control weeds including Palmer amaranth (*Amaranthus palmeri S. Watson*), waterhemp (*Amaranthus tuberculatus (Moq.) J. D. Sauer*), morningglory (*Ipomea spp.*), barnyardgrass (*Echinochloa crus-galli (L.) P. Beauv), and* several winter annuals at a rate range of 20 to 40 g ai ha^{-1}. *Rapidicil* has also been shown to have efficacy on confirmed PPO-, glyphosate-, and ALS-resistant weed species. It is recommended that *Rapidicil* be utilized as part of an integrated weed management strategy including the use of cultural practices and multiple modes-of-action to mitigate the development of resistance. *Rapidicil* is currently under review and pending EPA registration.

Herbicide-resistant Common Chickweed [*Stellaria media*(L.) Vill.] Populations and Yield Losses in Small Grain Crops in the Central Valley of California. Jennifer Valdez Herrera*[1], Anil Shrestha[2], Katherine Waselkov[2], Nicholas E. Clark[3]; [1]California State University, Fresno, Fresno, CA, [2]California State University, Fresno, CA, [3]University of California Cooperative Extension, Kings County, Hanford, CA (042)

Common chickweed (*Stellaria media*), a self-pollinating winter annual, has been observed invading triticale (×*Triticosecale*) and wheat (*Triticum aestivum*) fields treated with post-emergence ALS-inhibiting herbicides in the southern Central Valley (CV) of California. The steady rise of common chickweed resistance to ALS herbicides and its competitive potential with small grain production in the CV has been an increasing concern. The objectives of this study were to: (1) conduct dose response experiments to confirm the presence of ALS herbicide-resistant chickweed populations in the CV; (2) use genetics methods to determine the resistance mutations of the populations in the ALS gene; and (3) determine yield loss caused by common chickweed interference in forage wheat. Seeds of common chickweed populations were collected from organic fields with no ALS herbicide use history and from fields that had reported ALS herbicide escapes. A randomized complete block design with five replications of the treatments was used to screen common chickweed seeds for herbicide resistance with registered ALS herbicides imazamox, tribenuron, mesosulfuron, pyroxsulam, and imazethapyr. All populations tested were resistant to these herbicides. Sanger sequencing genetic methods were used to determine the basis of ALS-inhibitor resistance of these populations. Surveys carried out to assess the competitive effects of common chickweed on the biomass of wheat in weed-free and weed-infested plots showed that forage wheat dry weight was reduced by approximately 32% at crop harvest. Genetic studies are ongoing, and the dose response studies are being repeated, to determine the extent of the problem for CV growers.

Mechanism of Resistance to Pyroxulam in Italian Ryegrass. Shuo Wang*[1], Samuel R. Revolinski[2], Marija Savic[1], Shahbaz Ahmed[1], Ian Burke[1]; [1]Washington State University, Pullman, WA, [2]University of Kentucky, Lexington, KY (043)

Italian ryegrass is a noxious weed in North America and can greatly reduce yields in wheat fields it infests. Pyroxsulam is an effective, widely used herbicide for managing Italian ryegrass in the inland Pacific Northwest (PNW). However, resistance to pyroxsulam in Italian Ryegrass, conferred by unknown mechanisms, has been identified in the inland PNW. In this study, six susceptible biotypes and 30 biotypes putatively resistant to pyroxsulam were collected from the high rainfall zone of the inland PNW and investigated based on dose-response assays, ALS gene sequencing, and an absorption/translocation assay to reveal the mechanisms of resistance to pyroxsulam. Based on the dose-response assay, 18 biotypes were resistant to pyroxsulam in both trials, and the resistant indexes were 3.2 to >500-fold greater than the susceptible biotypes. ALS gene sequencing identified Pro-197-Leu and Asp-376-Glu mutations in two resistant biotypes, but no amino acid substitutions were detected in the other resistant biotypes. Pretreatment of malathion, a cytochrome P450 inhibitor, enhanced the sensitivity of Italian ryegrass to pyroxsulam. The results of the absorption and translocation assay showed there was no difference in the absorption of pyroxsulam between susceptible and resistant biotypes, but the translocation of pyroxsulam to the roots was limited in resistant biotypes. Mutations in target genes, enhanced

metabolism of cytochrome P450s, and movement restriction may be the mechanisms of resistance to pyroxsulam in Italian ryegrass. It is necessary to further monitor Italian ryegrass biotypes locally for resistance to pyroxsulam and to implement effective resistance management measures to delay resistance development.

Potential Interaction Between Cover Crops and Soil Nitrogen for Dry Edible Bean Growth and Development. Andrew R. Kniss, Ramawatar Yadav*; University of Wyoming, Laramie, WY (44) (044)

Fall-seeded cereal cover crops have shown to cause variable effects on dry edible bean yield. This could be attributed to cover crop mediated changes to plant available nitrogen or cover crop-induced main crop unknown responses. Field experiments were conducted in summer 2023 in Laramie, WY to quantify the interaction between the presence of cover crop in early-season and nitrogen fertility on dry bean growth and development. The study design included a 2 by 4 factorial arrangement of cover crop presence versus absence and four nitrogen rates ranging from 0 to 224 kg ha-1. Black plastic pails (19 L) were filled with a potting mix and nitrogen fertilizer. Kentucky bluegrass sod was used to simulate the presence of cover crop. Dry bean was planted in the center of pail surrounded by a cardboard tube to prevent early-season resource competition between the crop and grass. Shoots and roots of grass were trimmed as needed to prevent direct shading of dry bean and nitrogen uptake by the grass and the grass was removed when dry bean reached the one to two trifoliolate growth stage. Common responses to neighboring vegetation like leaf numbers flower/pod numbers were not affected by the presence of grass or nitrogen treatments. In the absence of fertilizer, most end-of-season dry bean growth parameters were lower in the grass treatments compared to the no grass treatments. In the absence of grass, nitrogen rate had no effect on leaf area ($P = 0.492$), aboveground vegetative biomass ($P = 0.618$), or pod biomass ($P = 0.190$). However, if grass was present, increasing nitrogen rate increased leaf area ($P = 0.006$), aboveground vegetative biomass ($P = 0.010$), and pod biomass ($P = 0.085$), even though the grass roots were not allowed to reach the depth at which fertilizer was applied. This suggests a potential interaction between early-season cover crop-reflected light and nitrogen fertility that could impact dry bean yield potential.

Weed Control with 2,4-D and Glufosinate Applied Alone, Mixed, and Sequentially in Soybean. David Vos, Jill Alms, Eric Jones*; South Dakota State University, Brookings, SD (045)

Field experiments were conducted in soybean to determine the effect of 2,4-D and glufosinate applied alone, mixed, and sequentially on pervasive weed species (common lambsquarters, redroot pigweed, yellow foxtail, and waterhemp) and yield. The experiment was conducted at Beresford (common lambsquarters and waterhemp) and South Shore (redroot pigweed and yellow foxtail), South Dakota during the 2023 growing season. Initial treatments were applied when the weeds were 15 cm in height. Sequential herbicide treatments were applied 12 days after the initial treatment. 2,4-D and glufosinate alone provided the least control of all tested weed species. Sequential treatments provided greater control for all tested species. However, two applications of glufosinate were needed to control yellow foxtail greater than 80%. 2,4-D + glufosinate additively controlled all tested weed species. Soybean yield was not different between the treated plots at Beresford. Soybean yield was greater with two applications of glufosinate compared to the other

treatments at South Shore. The results of the experiment provide evidence that 2,4-D and glufosinate are more effective on pervasive weed species when applied sequentially and what species are present may dictate how the herbicides are applied together. Sequential herbicide applications may be necessary to achieve higher yields based on the species present.

Response of Italian Ryegrass to Crop Rotation and Indaziflam in Eastern Washington. Marija Savic*[1], Kenton C. Lyman[1], Samuel R. Revolinski[2], Ian Burke[1]; [1]Washington State University, Pullman, WA, [2]University of Kentucky, Lexington, KY (046)

Italian ryegrass is a troublesome annual grass species in the dryland cropping systems that receive more than 400 mm of annual precipitation in PNW. Indaziflam is a group 29 herbicide with residual soil activity and a novel mechanism of action. A field study was conducted in eastern Washington - Almota and Pullman from 2020 through 2022 to evaluate crop injury, yield, and Italian ryegrass seedbank response to common wheat rotations with and without indaziflam. Indaziflam was applied postemergence in 2020 at 0, 22, and 44 g ai ha^{-1} in spring wheat. In 2021, barley, canola, chickpea, winter wheat, and fallow treatments were established within the 2020 plots. Crop yields were highly variable in Almota, and very low in Pullman due to drought. Barley, canola, and winter wheat yields were reduced due indaziflam treatment in 2020, whereas chickpea yields were unaffected. In 2022, indaziflam treatment was associated with an increase in winter (Almota) and spring (Pullman) wheat yield. At both locations in 2021 Italian ryegrass plant density, averaged across all crop rotation treatments, decreased with increasing indaziflam rates. In 2022, Italian ryegrass density decreased with increased rates of indaziflam, and seedbank density was affected by indaziflam rate. Indaziflam treatments applied in 2020 and planted to chickpeas in 2021 resulted in the lowest crop injury and the greatest reduction of Italian ryegrass seedbank in 2022. Indaziflam appears to be a useful component of integrated Italian ryegrass management in dryland wheat production, particularly when rotations include chickpeas.

Kentucky Bluegrass Response to Pyroxasulfone and Carfentrazone. Jessica E. R. Kalin*, Ian Burke; Washington State University, Pullman, WA (047)

Around 90% of Kentucky bluegrass (*Poa pratensis*) seed in the United States is produced in the Pacific Northwest. Winter annual weeds are difficult to manage in turfgrass grown for seed because they don't respond to currently labeled postemergence herbicides and Kentucky bluegrass does not compete well with annual weeds. Pyroxasulfone, which has soil residual activity, is a new herbicide being considered for use in Kentucky bluegrass. Two field trials were conducted to determine injury and efficacy of pyroxasulfone + carfentrazone herbicide treatments in established (>3 year old stand) and newly seeded Kentucky bluegrass in eastern Washington. Herbicide treatments did not cause injury in established bluegrass, though there was considerable injury in newly seeded bluegrass at high application rates. There was adequate weed control (>70%) in both established and newly seeded stands due to the herbicide treatments. Injury from herbicide in the newly seeded stand resulted in a substantial yield loss for those treatments. Pyroxasulfone + carfentrazone appears to be effective for annual grass weeds and is safe in both established bluegrass and safe at low rates in newly seeded Kentucky bluegrass.

Evaluation of Preemergence and Postemergence Herbicide Options in Soybean for Weed Control in Southwest North Dakota. Caleb D. Dalley*, Daniel Guimaraes Abe; North Dakota State University, Hettinger, ND (048)

In southwest North Dakota, soybean plantings are increasing each year as more growers become familiar with its production and want to use it as part of their crop rotation, which is dominated by small grains, particularly spring wheat. With this increased production, there is a need to determine best practices for weed control in this environment and in the no-till production systems that are nearly ubiquitous in western North Dakota, which differs from the primary soybean production area in eastern North Dakota where conventional tillage is prevalent. A trial was conducted in 2022 and 2023 to evaluate timing of PRE herbicide application compared with POST herbicide options. PRE treatments were applied at 2 and 1 week prior to planting and at planting. PRE herbicide treatments included flumioxazin (105 g ai ha^{-1}); flumioxazin + pyroxasulfone (105 + 183 g ai ha^{-1}), sulfentrazone + metolachlor (196 + 1770 g ai ha^{-1}), sulfentrazone + pyroxasulfone (178 + 178 g ai ha^{-1}), and sulfentrazone + metribuzin (27 + 340 g ai ha^{-1}). All PRE treatments were tank-mixed with glyphosate (840 g ae ha^{-1}), AMS (214 g L^{-1}), and HSMSO 1% v/v. PRE treatments were compared with dicamba + glyphosate (560 + 840 g ae ha^{-1}) applied at planting or when soybean were at the V1 growth stage; sequential applications of glyphosate (840 g ha^{-1}) applied at planting and at V1 soybean; and to sulfentrazone + metolachlor (196 + 1770 g ai ha^{-1}) applied PRE followed by glyphosate (840 g ha^{-1}) at V1 soybean. One hypothesis of this trial was that applying the PRE treatments earlier would result in better control of weeds such as kochia as there would be increased chance for activation through rainfall prior to weed emergence. However, we did not see this as a consistent response to timing of herbicide application. Flumioxazin alone as a PRE herbicide did not effectively control kochia where control ranged from 43 to 53% in 2022 and 57 to 74% in 2023. The addition of pyroxasulfone to flumioxazin increased kochia control to 53 to 67% in 2022 and 83 to 88% in 2023. Sulfentrazone plus metribuzin was consistently the best PRE treatment with kochia control ranging from 78 to 85% in 2022 and from 82 to 93% in 2023. Dicamba plus glyphosate applied PRE controlled kochia 64% in 2022 and 95% in 2023. In the week following the PRE application, there was 117 mm rain in 2022 and 174 mm in 2023. More than enough to activate the dicamba in the soil in both trials. However, the following week there was 524 mm of rainfall in 2022 and only 9 mm of rainfall in 2023. The higher rainfall in 2022 may have diluted the dicamba in the soil and stimulated emergence of additional kochia. Dicamba plus glyphosate applied POST controlled kochia 83% in 2022 and 95% in 2023. Sequential applications of glyphosate (PRE and POST) controlled kochia 78% in 2022 and 89% in 2023. In 2022, soybean yield increased with nearly all herbicide treatments compared to the untreated control. Yield was greatest in the sulfentrazone plus metribuzin treatments, when sulfentrazone plus pyroxasulfone was applied 1 week before planting, and with two applications of glyphosate. In 2023, soybean yields were higher when treatments were applied PRE, and when dicamba plus glyphosate (PRE and POST) and with sequential glyphosate applications. While the PRE herbicides did not perform better than the POST comparisons, it is important that we do not rely solely on POST herbicides for weed control in soybean as there is increased incidence of resistance to glyphosate and dicamba being reported in North Dakota and elsewhere.

Impact of Irrigation on Herbicide Activity in Cotton Production System. Jasleen S. Makkar*, Rupinder Saini, Preetaman Bajwa, Lindsey Slaughter, Sukhbir Singh; Texas Tech University, Lubbock, TX (049)

Herbicide performance depends on various environmental factors and irrigation levels. Increased concerns about water scarcity in semi-arid regions demand efficient irrigation management. This study investigates how varying irrigation levels affect herbicide efficacy in managing weeds in cotton production system. A field experiment was conducted at Quaker Research Farm of Texas Tech University in summer 2023. The experiment was randomized three times in a split-plot design with two irrigation levels: I1 [100% crop evapotranspiration (ETc)] and I2 [50% ETc] as main plot factor and six different herbicides combinations [T1: *S*- metolachlor as pre-emergent (PRE), T2: Acetochlor (PRE), T3: Prometryn (PRE), T4: *S*-metolachlor (PRE) followed by (fb) glyphosate + *S*-metolachlor as post-emergent (POST), T5: Acetochlor (PRE) fb glyphosate + acetochlor (POST), T6: Prometryn (PRE) fb glyphosate + prometryn (POST)] including untreated control as subplot factors. At 9 weeks after planting (WAP), treatments with post-emergence herbicide applications (T4-T6) significantly reduced total weed count and biomass. Prometryn (PRE) and treatments with post-emergence herbicide application reduced both Palmer amaranth density and biomass. Additionally, 50% irrigation level significantly suppressed Palmer amaranth growth and biomass as compared to 100% irrigation level. S-metolachlor (PRE) followed fb glyphosate + S-metolachlor (POST) and prometryn (PRE) fb glyphosate + prometryn (POST) yielded higher cotton biomass compared to untreated control while, S-metolachlor (PRE) followed fb glyphosate + S-metolachlor (POST) treated plots produced higher lint and seed yield. Based on results, S-metolachlor (PRE) fb glyphosate + S-metolachlor (POST)] significantly reduced weed infestation and produced maximum lint and seed yield at both irrigation levels.

Weed Control from Soil Residual Herbicides in Sugarbeet. Nevin Lawrence[1], Andrew R. Kniss*[2]; [1]University of Nebraska, Scottsbluff, NE, [2]University of Wyoming, Laramie, WY (050)

Herbicide-resistant weed management is the greatest production challenge currently facing sugarbeet growers nationwide. Resistance to postemergence herbicides like glyphosate and triflusulfuron are especially challenging, so growers are interested in evaluating a range of soil-applied herbicides. Field studies were conducted near Lingle, WY and Scottsbluff, NE in 2023 to evaluate efficacy of metamitron, ethofumesate, EPTC, pyrazon, cycloate, S-metolachlor, dimethenamid-P, and encapsulated acetochlor applied PRE. At Lingle, metamitron applied alone (3.47 kg ha^{-1}) or with ethofumesate (1.49 kg ha^{-1}) and pyrazon (4.1 kg ha^{-1}) provided the most consistent control of common lambsquarters and redroot pigweed. Pyrazon provided excellent common lambsquarters and Palmer amaranth control at Scottbluff.

Bulk Segregant Analysis Identifies Regions of the Genome Associated with Paraquat Resistance in *Conyza sumatrensis*. Ana Beatriz Amaral de Macedo[1], André Lucas Simões Araujo[2], Jacob S. Montgomery[2], Eduardo Amorim[1], Jessica Leal[3], Sarah Morran[2], Todd A. Gaines[2], Camila Ferreira Pinho*[1]; [1]UFRRJ - Federal Rural University of Rio de Janeiro, Seropédica, Brazil, [2]Colorado State University, Fort Collins, CO, [3]UPL Brazil, Pereiras, Brazil (051)

Abstract not Available

Effect of Cover Crop Presence on Herbicide Efficacy. Madison L. Wright*, Ramawatar Yadav, Andrew R. Kniss; University of Wyoming, Laramie, WY (052)

Shade avoidance syndrome (SAS) is a plant response to neighboring vegetation, including cover crops. It was hypothesized that cover crops could alter herbicide efficacy due to the relationship between SAS and herbicide injury pathways. Field experiments in sugar beet and dry edible bean were completed in 2023 near Lingle, WY. A split-plot randomized complete block design with four replicates was used in both studies. A winter wheat cover crop (presence or absence) was the whole-plot, and herbicide treatments were applied as the split-plot, allowing herbicide injury to be evaluated with and without the presence of wheat. The wheat was terminated in the sugar beet study at the two true-leaf stage and in the dry bean study 2 d before planting (before crop emergence). The herbicides acifluorfen, clopyralid, and a pre-mix of phenmedipham, desmedipham, and ethofumesate were applied in the sugar beet study at the 2 to 4 true-leaf stage. Bentazon, imazamox, and fomesafen were applied in the dry bean study at the 1 to 2 trifoliolate stage. Weeds were removed by hand to exclude confounding effects of weed competition. Wheat presence reduced sugar beet biomass by 28% and acifluoren was the only herbicide that reduced sugar beet biomass, regardless of whether the wheat was present or not. Without herbicides, dry edible bean yield was reduced 16% in the presence of wheat. In the absence of wheat, no herbicides reduced yield significantly compared to the nontreated control; however, imazamox reduced dry bean yield if the wheat was present.

Evaluation of Dicamba, Glyphosate, and Glufosinate-Resistant Sugar Beet Across the Western Production Region. Abraham Akuoko*[1], Albert T. Adjesiwor[2], Joel Felix[3], Andrew R. Kniss[4], Nevin Lawrence[5]; [1]University of Nebraska, Lincoln, NE, [2]University of Idaho, Kimberly, ID, [3]Oregon State University, Ontario, OR, [4]University of Wyoming, Laramie, WY, [5]University of Nebraska, Scottsbluff, NE (053)

Truvera® is a novel sugar beet trait resistant to dicamba, glyphosate, and glufosinate. Regulated trials were conducted to evaluate weed control in Scottsbluff, NE; Lingle, WY; Kimberly, ID; and Ontario, OR in 2023. The trial was designed as a two-factor split-strip set in a RCBD. The strip-plot factor was glyphosate or dicamba + glyphosate applied PRE. The main factor was POST herbicide applied at 2-4 TL, and again at 6-8 TL. A total of ten POST herbicides were applied which allowed for every combination of glyphosate + dicamba, glyphosate, or glufosinate to be applied across the two timings with the addition of a non-treated check. Weed control was assessed by species through visually estimating control, and by counting emerged weeds in each plot. Weed control assessment occurred prior to the second POST application and 2-11 weeks after the second POST application, depending on the site location. Common lambsquarters, redroot pigweed, and kochia were present at the WY, ID, and OR locations; and common lambsquarters and glyphosate-resistant Palmer amaranth were present in NE. Dicamba PRE significantly reduced common lambsquarters, redroot pigweed, and kochia across all locations. All POST herbicide combinations were effective at reducing common lambsquarters, redroot pigweed, and kochia density compared to the non-treated check. The use of dicamba PRE had no impact on Palmer amaranth density. Glufosinate followed by glufosinate, dicamba + glyphosate followed by glufosinate, and dicamba

+ glyphosate followed by dicamba + glyphosate were the most effective POST treatments for Palmer amaranth.

Herbicide Resistant Italian Ryegrass Survey in Northern Idaho and Eastern Washington. Traci Rauch*, Joan Campbell; University of Idaho, Moscow, ID (054)

The Pacific Northwest of the United States is a productive wheat growing region with significant yield loss from annual grass weeds. Persistent use of herbicides with the same modes of action has resulted in the selection of many herbicide-resistant weeds. Resistance to herbicides used for annual grass control is a problem for farmers in the region. A survey of 96 fields in the Palouse region of the inland Pacific Northwest was conducted to determine the extent of Italian ryegrass resistance to grass herbicides commonly used in winter wheat-cropping systems. Plants were grown from collected seed samples in a greenhouse and were tested for resistance to triasulfuron, flufenacet/metribuzin, metolachlor, dimethenamid, and pyroxasulfone. Triasulfuron is a ALS-inhibiting herbicide used in wheat and resistance was observed at 93% in the populations tested. This is a large increase compared to a survey of 75 fields in the same region in 2007 which triasulfuron resistance was 44%. Flufenacet/metribuzin is in wheat and has two modes of action, inhibiting very long chain fatty acid synthesis (LCFA) and photosystem II electron transfer. Resistance occurred in 30% of the population tested in 2018 compared to 12% in the 2007 survey. Dimethenamid and metolachlor are both LCFA inhibitors used in legume crops in our wheat production system and resistance was observed at 3 and 19%, respectively. All populations tested were susceptible to pyroxasulfone which is a LCFA-inhibiting herbicide used in wheat. Populations susceptible to all four LCFA-inhibiting herbicides occurred at 64%. Only 7% of populations were completely susceptible to all 5 herbicides tested. These results indicate that herbicide-resistant Italian ryegrass populations are increasing across much of the Palouse region in northern Idaho and eastern Washington.

Crop Safety Evaluation of Dichlorprop-p and Bromoxynil Preplant Applications. Daniel Beran*[1], Bob Bruss[2]; [1]Nufarm, Eldora Us, IA, [2]Nufarm, Morrisville, NC (055)

Dichlorprop-p is a group 4 phenoxy herbicide being developed by Nufarm for the management of herbicide resistant plants. Efficacy studies conducted from 2019-2023 have indicated promising levels of control of kochia (*Bassia scoparia*) with dichlorprop-p, including biotypes resistant to 2,4-D, dicamba and fluroxypyr. A premix herbicide with dichlorprop-p plus bromoxynil has been developed for postemergence weed control in wheat and barley. A second premix herbicide with dichlorprop-p plus dicamba and 2,4-D has been developed for use in fallow. To evaluate the potential for these active ingredients and premix herbicides for preplant burndown, crop safety studies were conducted on corn (*Zea mays* L.), soybean [*Glycine max* (L.) Merr.], dry bean (*Phaseolus vulgaris* L.) and sunflower (*Helianthus annuus* L.). Field corn trials established on no-till and conventional tillage sites in Nebraska and Minnesota indicated that there is acceptable crop safety to dichloprop-p at preplant and preemergence timings to allow for an effective rate of 0.56 kg ai ha^{-1}. Similarly, soybean trials conducted on no-till and conventional tillage sites in Nebraska, Kansas and Minnesota indicated acceptable crop safety to dichlorprop-p in no-till settings when applied 7 days or more prior to planting at 0.56 kg ai ha^{-1}. A third set of trials was conducted in North Dakota to evaluate the potential of a dichlorprop-p plus bromoxynil premix herbicide as a

burndown herbicide for soybean, pinto bean and sunflower. When applied 7 days prior to planting, the treatment of 0.56 kg dichlorprop-p ha^{-1} plus 0.28 kg bromoxynil ha^{-1} resulted in low levels of crop response in soybean, pinto bean and sunflower. The results of these studies indicate that dichlorprop-p may be an alternative active ingredient for preplant burndown particularly in cropping systems where kochia is an early emerging competitive weed. Further studies will be required to expand the understanding of crop safety interactions with soil types, rainfall, crop varieties, as well as with dichlorprop-p based herbicide mixtures that will be needed for resistance management.

Scorch EXT and Maestro EXT: Dichlorprop-p Based Herbicides for Management of Kochia in Fallow and Small Grains. Daniel Beran*[1], Bob Bruss[2]; [1]Nufarm, Eldora Us, IA, [2]Nufarm, Morrisville, NC (056)

Dichlorprop-p is a group 4 phenoxy herbicide developed by Nufarm that has benefits for the management of herbicide resistant plants. Dichlorprop-p, has been used under a special local need label in Texas for post-harvest crop destruction of cotton including 2,4-D tolerant varieties. Efficacy studies conducted from 2019 to 2023 have indicated promising levels of kochia (*Bassia scoparia*) control, including biotypes resistant to 2,4-D, dicamba and fluroxypyr. Scorch EXT, a premix combination of dichlorprop-p, dicamba and 2,4-D is registered for noncropland use and is pending registration for fallow and preplant usage. Trials conducted in 2022-2023 evaluated the impact of kochia size and tank mixtures on control with Scorch EXT. Averaged across 11 sites, Scorch EXT at 24 oz/A (0.5 lb dichlorprop-p + 0.25 lb dicamba + 0.25 lb 2,4-D) provided 85% control 2-4" kochia. Control at this timing improved to 95% when Panther SC at 2 fl. oz/A (0.063 lb flumioxazin) was tank mixed with Scorch EXT. In contrast, control of 4-8" kochia was 76% and 92% when Scorch EXT was applied alone and with Panther SC, respectively. Dichlorprop-p is also being developed in a premix with bromoxynil (Maestro EXT) for use in wheat and barley. Maestro EXT has demonstrated excellent kochia control, averaging 91% when applied at 20 oz/A (0.5 lb dichlorprop-p + 0.25 lb bromoxynil) and 95% when applied at 30 oz/A (0.75 lb dichlorprop-p + 0.375 lb bromoxynil). Further studies in small grains have indicated that dichlorprop-p has excellent compatibility with grass herbicides and crop safety.

Pre-plant Burndown of Conyza spp. in soybeans using atrazine + mesotrione and the evaluation of changes in leaf structure, weed germination timing, and plant back intervals. Pedro Antonio Vougodo Salmazo*[1], Paulo V. Da Silva[1], Claudia A.l. Cardoso[2], Arthur C. Sanches[3], Elias S. Medeiros[3], Mirella F. Ortiz[4]; [1]Universidade Federal da Grande Dourados, Dourados, Brazil, [2]Universidade Estadual de Mato Grosso do Sul, Dourados - Ms, Brazil, [3]Universidade Federal da Grande Dourados, Dourados - Ms, Brazil, [4]Utah State University, Logan, UT (057)

Preplanting of Conyza spp. burndown results in different effects on leaf structure and residual herbicides in the soil, influencing soybean selectivity. The objective of this work was to evaluate the effects of preplanting Conyza spp. burndown at different intervals before soybean planting on the control of and damage to the leaf structure. The experiment was conducted in the field with Conyza spp. infection and in the laboratory. The experimental design was a randomized block with four replications. Atrazine + mesotrione + tryclopyr (500+50+1020 g.i.a ha^{-1}) was applied 45, 30,

15 and 0 days before soybean sowing (DAS), and ammonium glufosinate (500 g.i.a ha^{-1}) was applied 10 days after the initial application. The parameters used were the percentage control of Conyza spp., germination flow analysis, atrazine quantification by high-performance liquid chromatography (HPLC) and scanning electron microscopy (SEM). All the statistical analyses were conducted using R software. At 14 days after application (DA), the heights at 0-5 cm and 5-10 cm did not significantly differ between 0 and 45 DAS, while the control height was greater than 85%. The atrazine residual was 389.1 g.i.a ha^{-1} at 30 DAA and 193.3 g.i.a ha^{-1} at 42 DAA. At 0 DAS, soybean plants exhibited 11.25% phytotoxicity. The concentration of atrazine in the soil was 415.75 g.i.a ha-1 at 14 DAS. On SEM, the Conyza spp. plants were shown to have long tector trichomes with tapered tips that were unicellular. Early application of the proposed method provides effective control of Conyza spp., with 15 and 30 days being considered selective for soybean plants.

Halauxifen + Diclosulam in Association with Other Herbicides in Pre-plant of Soybeans ENLIST: Control of Conyza Spp., Changes in Leaf Structure and Membrane Damage. Mateus S. Monteiro*[1], Paulo V. Da Silva[2], Pedro Antonio Vougodo Salmazo[2], Cleberton C. Santos[1], Silvana P. Q. Scalon[1], Elias S. Medeiros[1]; [1]Universidade Federal da Grande Dourados, Dourados - Ms, Brazil, [2]Universidade Federal da Grande Dourados, Dourados, Brazil (058)

This study evaluated the effectiveness of combining the herbicide 2,4-D with other postemergence herbicides for the control of *Conyza* spp. at different times after application. The experiment was conducted in the field using 2.4 D-tolerant soybeans in accordance with a randomized block design. Combinations of herbicides, including halauxifen + diclosulam alone and together with saflufenacil, thiafenacil, fomasafen and flumetsulam, were applied both in the presowing desiccation of soybeans and in sequential applications of glufosinate ammonium. Single applications were carried out before and after soybean sowing. The results showed that the combination of halauxifen + diclosulam in combination with saflufenacil and tiafenacil resulted in more than 90% control 21 days after application. Phytotoxic effects were observed on soybean plants following flumetsulam application. The chlorophyll content and potential quantum efficiency of photosystem II were greater in the treatment with halauxifen + diclosulam + flumetsulam. In the scanning electron microscopy analysis, long tector trichomes were observed on *Conyza* spp. plants. It is concluded that herbicide combinations with halauxifen + diclosulam can be effective in the management of *Conyza* spp., but it is necessary to consider the effects on the physiology of the weeds and the selectivity for soybean plants.

Indaziflam Reduces Downy Brome Seedbanks in Wheat-Fallow Systems in Eastern Washington. Weston Maughan*, Mariana F B Amaral, Marija Savic, Jessica E. R. Kalin, Ian Burke; Washington State University, Pullman, WA (059)

Indaziflam may be a potential tool for dryland wheat growers for management of downy brome (Bromus tectorum L.), mostly due to activity on germinating seedlings combined with relatively low soil mobility. Downy brome is a common and troublesome weed throughout many of the wheat producing areas of the Western United States and is particularly problematic in wheat-fallow systems of the inland Pacific Northwest. While indaziflam is a known effective tool for managing downy brome based on assessments of biomass, the herbicide's impacts on seedbanks have not

been assessed. The objective of the present study was to quantify downy brome seed presence in the soil seedbank in response to indaziflam-inclusive treatments. Many of the indaziflam-inclusive treatments had lower downy brome seedbank density than control treatments; however, because of the natural variation in the density of downy brome seeds in the soil seedbank, results were not significant at the alpha = 0.05 level. By reducing overall fecundity, indaziflam could be contributing to the long-term decline of downy brome seedbanks in the experiment. The use of indaziflam in wheat-fallow systems could be complemented by activities that induce seed germination in the zone of treated soil, potentially hastening the decline of the downy brome seedbank.

Building a Weed Seed Database from the Field of Inland Pacific Northwest. Shahbaz Ahmed*, Marija Savic, Jessica E. R. Kalin, Ian Burke; Washington State University, Pullman, WA (060)

The knowledge of weed seeds present in the soil seed bank is important for understanding population dynamics and forecasting future weed infestations. Quantification of the weed seed bank has historically been laborious, and few studies have attempted to quantify seedbanks on the scale required to make management decisions. An accurate, efficient, and ideally, automated method to identify weed seeds in field samples is needed. To achieve sufficient precision, we leveraged YOLOv8, a machine-learning object detection to accurately identify and count weed seeds obtained from the soil seed bank. The YOLOv8 model, trained and evaluated using high-quality images captured with a digital microscope, achieved an average accuracy and precision exceeding 80% confidence in distinguishing various weed seed species in both images and real-time videos. Despite the challenges associated with species having similar seed morphology, the application of YOLOv8 will facilitate rapid and accurate identification of weed seeds for future weed management trials.

Mature Alfalfa Tolerance to Flaming. Stevan Knezevic*[1], Luka Milosevic[2], Jon Scott[3], Chris Bruening[3], George Gogos[3]; [1]University of Nebraska - Lincoln, Concord, NE, [2]University of Nebraska - Lincoln, Department of Agronomy and Horticulture, Lincoln, NE, [3]University of Nebraska - Lincoln, Lincoln, NE (61) (061)

Alfalfa is the fourth most planted crop in the United States. Organic alfalfa is common rotational crop in organic cropping systems. Flaming, as a method for weed control, is also commonly utilized in many organic row crops and there is interest for use in organic alfalfa. Therefore, objective of this study was to provide some baseline data on alfalfa tolerance to heat. In 2021 and 2022, experiments were conducted at two local farms with a 4-year old alfalfa stand. Studies consisted of 6 propane rates and 3 flaming times utilizing a split-plot design with 3 replications. The main plot was alfalfa height (10cm, 20cm and 30cm) and the sub-plot were 6 flaming doses (0, 6, 9, 12,15, and 18 GPA). Visual ratings of percent alfalfa injury were conducted at 7 days after the flaming treatment (DAT), 14, and 21 DAT, utilizing a scale from 0 to 100 (where 0 = no injury and 100 = plant death). Each plot was 3m wide (width of a 4-row flamer) and 15m long. In general, alfalfa exhibited good level of tolerance to heat, and all injuries were temporary. For example, the 12 GPA rate (recommended propane rate for weed control), resulted in 60%, 70% and 40% injury level for 10, 20 and 30 cm tall alfalfa at 7 DAT, respectively. By 21 DAT the injury rating were 23%, 30 and 8%, respectively, indicating crop recovery. The highest propane rate (18 GPA) caused

90%, 80% and 70% injury levels for 10, 20 and 30 cm tall alfalfa at 7 DAT, respectively. By 21 DAT the injury rating were 40%, 50% and 40%, respectively. These preliminary results are showing good alfalfa tolerance to heat. This is also indicating potential for use of flaming as a tool for weed control in alfalfa. Additional data analysis is needed to confirm our initial conclusions.

WSWS Project 4. Teaching and Technology

Field Experiences for Effective Weed Management: the Promise of Co-Produced Student-Led Invasive Plant Surveys. Jacob Courkamp*; Colorado State University, Fort Collins, CO (062)

Weed management represents an important career track for students studying rangeland ecology and natural resource management, and weed managers working in rangelands and natural areas are in constant need of information to more effectively target their weed management activities. I present a case study from northern Colorado wherein student-led surveys in fall 2022 and 2023 identified patches of Russian knapweed (*Acroptilon repens* L.) at the Waverly Ranch (Waverly), a research property owned by the Department of Forest and Rangeland Stewardship at Colorado State University. The results of each student-led knapweed survey were used to guide subsequent knapweed treatments, and follow-up monitoring suggests that treatments have effectively eliminated knapweed at the scale of individual knapweed patches (40-1400 m^2). The success of this project suggests that the iterative process of student-led invasive plant surveys and subsequent treatment is an effective management strategy that may promote near-complete invasive plant eradication at the scale of individual pastures and open-space areas; this while providing students with valuable field experience that is likely to contribute to their future career success. University instructors should develop relationships with local land managers and work with them to expand this approach in the future, potentially addressing a wider variety of invasive plant species and integrating newer technologies (e.g., UAVs) to increase relevance to students and expand surveys to larger areas.

From Stress to Success: Hormesis Explained. Luka Milosevic*[1], Stevan Knezevic[2]; [1]University of Nebraska - Lincoln, Department of Agronomy and Horticulture, Lincoln, NE, [2]University of Nebraska - Lincoln, Concord, NE (063)

"Poison is in the dose," a concept known by toxicologists for centuries, dating back to the renowned Renaissance physician and alchemist Paracelsus (1494-1541). In the field of agriculture and crop production, this long-established principle takes on a novel and scientifically intriguing perspective. Faced with the escalating demand for food and the constraints of limited resources, we find ourselves at the crossroads of an ever needed increase in food production. Perhaps a novel approach to enhancing crop productivity is not only through traditional methods of crop breeding and crop protection, but through harnessing the potential occurrence of hormesis. It is dose-response phenomenon in which exposure to a low dose of a chemical agent (or environmental factor) that is detrimental at higher doses induces an adaptive beneficial effect on the cell (or organism). However, as we embrace the concept of hormesis, we also confront a significant

challenge for weed science discipline. It becomes evident that certain herbicides doses intended to control weeds, can paradoxically enhance the growth of other weed species. Therefore, the objective of this presentation is to provide (1) general overview of hormesis in the herbicide – plant interaction, utilizing *drc* package in R software environment and (2) briefly explain "up-to-date" statistical techniques for analysis of hormesis dose-response curves. By utilizing our unpublished data , we aimed to show how to provide comprehensive graphical and statistical evidence of hormesis, shedding light on this often-overseen phenomenon by weed scientists.

Advancing Weed Science Research, Extension, and Education: NIFA Grants and Panel Reviewer Opportunities. Annu Kumari*[1], Cynthia Sias[2], James Kells[3], Vijay Nandula[4], Lee Van Wychen[5]; [1]Crop, Soil & Environmental Sciences Department, Auburn University, Auburn, AL, [2]Virginia Tech, Blacksburg, VA, [3]Michigan State University, East Lansing, MI, [4]USDA, Stoneville, MS, [5]Weed Science Society of America, Alexandria, VA (064)

The United States Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA) administers competitive research, extension, and education programs in support of US agriculture. Several of these programs fund research and extension projects related to weed science along with other pest disciplines. Traditionally, a large number of successful weed science-focused project awards came from the Crop Protection and Pest Management (https://www.nifa.usda.gov/grants/funding-opportunities/crop-protection-pest-management) and the Agricultural and Food Research Initiative Foundational and Applied Science's (AFRI FAS, https://www.nifa.usda.gov/grants/programs/agriculture-food-research-initiative-afri/afri-foundational-applied-science-program) Pests and Beneficial Species of Agricultural Production Systems programs. However, there are several other programs that could be relevant to weed scientists. Some of these include, AFRI FAS - Critical Agricultural Research and Extension (CARE), IR-4 (https://www.nifa.usda.gov/grants/funding-opportunities/minor-crop-pest-management-program-interregional-research-project-4-ir), Methyl Bromide Transition (MBT, https://www.nifa.usda.gov/grants/funding-opportunities/methyl-bromide-transition-program), organic programs - Organic Agriculture Research and Extension Initiative (OREI, https://www.nifa.usda.gov/grants/funding-opportunities/organic-agriculture-research-extension-initiative) and Organic Transitions (ORG, https://www.nifa.usda.gov/grants/funding-opportunities/integrated-research-education-extension-competitive-grants-program-0), and Specialty Crop Research Initiative (SCRI, https://www.nifa.usda.gov/grants/funding-opportunities/specialty-crop-research-initiative). Additionally, several AFRI FAS program area priorities are available for projects involving interdisciplinary research and extension. Weed scientists are strongly encouraged to consider submitting proposals to these USDA-NIFA competitive grant programs. Weed scientists, especially early- and mid-career academic scientists, are also encouraged to volunteer to serve on a USDA-NIFA proposal review panel. Weed science representation on review panels is important and serving on a review panel is a great way to improve proposal-writing skills and build professional networks. Click on this link https://prs.nifa.usda.gov/prs/volunteerPrep.do to volunteer. Volunteering simply places your name on a list of candidate reviewers. There is no commitment until you are contacted by a USDA-NIFA Panel Manager/Program Director and agree to serve on a specific panel. (Copy and paste the respective URL links in a new tab or window of your web browser)

Developing a Decision Support System to Aid in Selection of Multiple Mode of Action Tank Mixes. Breanne D. Tidemann*[1], Gregory Innes[1], Christine Cock[2], Charles M. Geddes[3]; [1]Agriculture and Agri-Food Canada, Lacombe, AB, Canada, [2]Agriculture and Agri-Food Canada, Summerland, BC, Canada, [3]Agriculture and Agri-Food Canada, Lethbridge, AB, Canada (065)

Incorporation of multiple effective modes of action into a herbicide tank mix is a standard best management practice for mitigation and management of herbicide resistance. There is frustrations expressed by producers in trying to incorporate this integrated weed management tactic due to complexity of managing weed communities, and confusing marketing for herbicides. A decision support system that simplified the selection of herbicide tank mix partners to those that would provide a multiple effective mode of action tank mix would be a useful tool. This decision support system utilizes Pesticide Information Database from Health Canada and first filters that database to current herbicides. There is then pre-processing steps needed to standardize weed names, and herbicide nomenclature, as well as a manually developed database of tank-mix partners. This step could not be automated due to diversity in herbicide label design. The system will allow producers to select a weed of interest, identify any known herbicide resistance, select a crop and select a herbicide. From there a list will be generated of registered or supported tank mixes that would provide multiple effective modes of action on that weed species in that particular crop. The system is currently still under development.

The Importance of Communicating Agricultural Science and Technology, the Role of CAST, and You! Gregory K. Dahl*[1], Jill Schroeder[2], Thomas J. Peters[3], Anthony L. Witcher[4], Gray Turnage[5]; [1]Winfield United Retired, Eagan, MN, [2]New Mexico State University, Las Cruces, NM, [3]North Dakota State University, Fargo, ND, [4]Tennessee State University, McMinnville, TN, [5]Mississippi State University, Starkville, MS (066)

The Council for Agricultural Science and Technology (CAST) was established in 1972 as a nonprofit group and is composed of many scientific/professional societies, universities, nonprofit organizations, companies, and individuals. CAST convenes and coordinates networks of experts to assemble, interpret, and communicate credible, unbiased, science-based information to policymakers, the media, the private sector, and the public. The wide distribution of CAST publications to non-scientists enhances the education and understanding of topical agricultural issues to the public. At a time when the internet has made it more difficult to separate accurate and inaccurate information, it has never been more critical for reputable sources to deliver trusted, non-partisan information from authorities in their respective fields. Our primary work is the publication of task force reports, commentaries, special publications, and issue papers written by volunteer experts from many disciplines covering topics related to Food Sciences, Agricultural Technology, Animal Sciences, and Plant and Soil Sciences. Weed science is well represented on the CAST Board of Representatives Plant Agriculture and Environmental Issues Work Group with members from WSSA, NEWSS, NCWSS, WSWS, SWSS, and APMS. Board representatives welcome input from the members of our organizations on how CAST can enhance communication of science to more audiences and on topics of concern that need to be addressed through CAST publications. Becoming a CAST individual member is easy, free for students, and one of the best ways to stay informed on the science and technology of food and modern agriculture.

2023 Survey Results for the Most Common and Troublesome Weeds in Grass Crops, Pasture, and Turf. Cynthia Sias[1], Annu Kumari[2], Lee Van Wychen*[3]; [1]Virginia Tech, Blacksburg, VA, [2]Crop, Soil & Environmental Sciences Department, Auburn University, Auburn, AL, [3]Weed Science Society of America, Alexandria, VA (067)

The 2023 Weed Survey for the U.S. and Canada surveyed the most common and troublesome weeds in the following grass crops: 1) corn (*Zea mays*); 2) rice (*Oryza sativa*); 3) sorghum (*Sorghum bicolor*); 4) spring cereal grains; 5) winter cereal grains; 6) pastures, rangeland, or other hay; and 7) turf. Common weeds refer to the weeds you most frequently see while troublesome weeds are the most difficult to control but might not be widespread. There were 258 survey responses from the U.S. and Canada. In corn, the top five most common weeds were 1) common lambsquarters (*Chenopodium album*); 2) waterhemp (*Amaranthus tuberculatus*); 3) morningglory species (Ipomoea spp.); 4) Palmer amaranth (*Amaranthus palmeri*)*; 5)* giant foxtail *(Setaria faberi).* The most troublesome weeds in corn were 1) waterhemp; 2) morningglory spp.; 3) Palmer amaranth; 4) johnsongrass (*Sorghum halepense*); and 5) kochia (*Bassia scoparia*). In rice, the top three most common weeds were 1) Cyperus spp.; and 2) a tie between barnyardgrass (*Echinochloa crus-galli)* and Amazon sprangletop (*Diplachne panicoides)*. The three most troublesome weeds in rice were 1) Echinochloa spp.; 2) sprangletop spp.; and 3) a tie between Oryza spp. and Cyperus spp. In sorghum, the top three most common weeds were 1) Palmer amaranth 2) johnsongrass; and 3) a tie among kochia; morningglory spp.; and pigweed spp. The top three most troublesome weeds were: 1) johnsongrass; 2) Palmer amaranth; and 3) kochia. In spring cereal grains, the top three most common weeds were: 1) a tie between common lambsquarters and wild oat (*Avena fatua*); and 3) kochia. The top three most troublesome weeds in spring cereal grains were 1) wild oat; 2) kochia; and 3) green foxtail (*Setaria viridis)*. In winter cereal grains, the top five most common weeds were 1) henbit (*Lamium amplexicaule*); 2) common chickweed (*Stellaria media*); 3) downy brome (*Bromus tectorum*); 4) Italian ryegrass (*Lolium perenne ssp. Multiflorum*); and 5) annual bluegrass (*Poa annua*). The most troublesome weeds were: 1) downy brome; 2) a tie between horseweed (*Conyza canadensis*) and Italian ryegrass; 4) annual bluegrass; and 5) kochia. In pastures, rangeland, and other hay, the top five most common weeds were 1) Canada thistle (*Cirsium arvense*); 2) horsenettle (*Solanum carolinense*); 3) dandelion (*Taraxacum officinale*); and 4) a tie between downy brome and musk thistle (*Carduus nutans*). The most troublesome weeds were 1) Canada thistle; 2) leafy spurge (*Euphorbia esula*); 3) horsenettle; 4) downy brome; and 5) johnsongrass. In turf, the top five most common weeds were 1) dandelion; 2) annual bluegrass; 3) white clover (*Trifolium repense*); 4) smooth crabgrass (*Digitaria ischaemum*); and 5) goosegrass (*Eleusine indica*). The most troublesome weeds were: 1) a tie between annual bluegrass and bermudagrass (*Cynodon dactylon*); 3) goosegrass; 4) yellow nutsedge (*Cyperus esculentus*); and 5) dallisgrass (*Paspalum dilatatum*). Overall, the top five most common weeds among all grass crops were 1) common lambsquarters; 2) kochia; 3) dandelion; 4) Canada thistle; and 5) Palmer amaranth. The most troublesome weeds were: 1) kochia; 2) Canada thistle; 3) johnsongrass; 4) Palmer amaranth; and 5) annual bluegrass.

What Should Undergraduate Students Learn About Applied Plant Protection? Randa Jabbour*, Clint W. Beiermann; University of Wyoming, Laramie, WY (068)

Plant protection by producers and land managers spans disciplines such as entomology, weed science, plant pathology, and wildlife management. Educators, often focused within a given discipline, have the opportunity and challenge to teach students knowledge and skills that they can apply in this broader context. At our home institution, the University of Wyoming, a lecture-based class on the Ecology of Plant Protection has long been co-taught by an entomologist, weed scientist, and plant pathologist. In Fall 2023, we offered for the first time an Applied Plant Protection lab course, again co-taught by faculty spanning these three disciplines. We will present on our development of a competency inventory for this course. One example of a relevant competency would be "I can identify insects to the order level." This inventory will provide a foundation for future development of this course, and more broadly, our Plant Protection minor. We also plan to use the inventory for student self-assessment and instructor assessment. Finally, next steps for this project include surveying external stakeholders and employers on which competencies they consider as highest priority for students.

Educational Strategies for Sustainable Weed Control in Agricultural Systems with Crop Rotation in the State of Mato Grosso Do Sul Under a Climate Change Scenario. Paulo V. Da Silva*[1], Munir Mauad[2], Mirella F. Ortiz[3]; [1]Universidade Federal da Grande Dourados, Dourados, Brazil, [2]Universidade Federal da Grande Dourados, Dourados-ms, Brazil, [3]Utah State University, Logan, UT (069)

The state of Mato Grosso do Sul has presented recent reports of resistant weed biotypes and is close to the states of Mato Grosso and western Paraná, facilitating the dissemination of biotypes established in these other regions. On several properties, the soybean-corn rotation system predominates, which is associated with climate change and has favored the adaptation, establishment, and dissemination of certain resistant biotypes of weeds. The objective of this work was to demonstrate pedagogical and research strategies to reduce the spread and establishment of resistant biotypes of weeds in the state of Mato Grosso do Sul. The pedagogical strategies at the Federal University of Grande Dourados (UFGD) are divided into undergraduate courses on agronomy and Management of Herbicides-Resistant Weed Plants and Weed Plant Biology. In the Graduate Program of Agronomy, Initiation to Scientific Research in Weeds and chemical control of weeds are offered (last offer together with the Federal University of Paraná and State University of Maringá). In these classes, aspects of the ecophysiology of weeds (*Conyza* spp., *Digitarias insularis*, species well established in the region and, recently, *Amaranthus* spp., *Euphorbia* spp. and *Bidens* spp.) have been studied. The classes cover how the intercropping and rotation of crops have an impact on the dynamics of weeds, with a focus on corn associated with *Brachiaria decubens*, as well as alternatives to soybean– corn rotation, aiming at the ecological nonadaptability of weeds in cultivation systems. The practices are effective because many students go to industry and use the concepts.

WSWS Project 5. Basic Biology and Ecology

Wind Speed and Nozzle Orientation Impact on Spray Patterns in Wind-Tunnel Experiments. Gabriel de Souza Lemes*[1], Aleksandra Pantic[1], Taylor Lundgreen[2], Jeffrey Golus[3],

Milos Zaric[3]; [1]University of Nebraska, North Platte, NE, [2]University of Nebraska, Lincoln, NE, [3]University of Nebraska - Lincoln, North Platte, NE (012)

The influence of environmental conditions on the performance and effectiveness of spot sprayers, particularly regarding factors like wind, is not yet fully understood. This study explores the implications of different wind speeds on spray pattern deposition under controlled conditions. The experiment was carried out on a custom-made tray with 12 mm diameter tubes spaced 16 mm off-center. Wind speeds of 0, 2.68, and 5.36 m s^{-1} were used to investigate the influence on the spray pattern deposition of two nozzles. Nozzles TP3003E-SS and TPU6503E-SS, with 71.1 and 29.9 cm boom heights, were selected to attain a 38.1 cm pattern width, respectively. Tests on each nozzle were conducted at three orientations relative to the wind direction perpendicular (0 degrees), cross (45 degrees), and parallel (90 degrees). The study demonstrates that the orientation of the nozzle concerning the wind direction has a notable impact on the dispersion of the spray pattern. For instance, when applying TP3003E-SS at a velocity of 5.36 m s^{-1}, positioning the nozzle perpendicular to the wind direction led to a 64% increase in the deposition area and a 16 cm displacement of the pattern. Such alterations in area and pattern displacement could potentially result in the delivery of a reduced dosage or even missing the target altogether. Oppositely, aligning the nozzle parallel to the wind had the least effect on increasing the pattern area and displacement. Those findings might serve as a valuable resource, influencing future software algorithm enhancements, guiding decision-making processes, and optimizing spray applications.

The Role of Cytokinin and Sucrose on 2,4-D Rapid Response of *Conyza sumatrensis*. Luisa C. Baccin*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (013)

In *Conyza sumatrensis*, distinct leaf tissue senescence, known as rapid response (RR), occurs shortly after exposure to 2,4-D herbicide. This study investigates RR in two 2,4-D resistant biotypes, B6 and B9, focusing on the effects of developmental stage, cytokinin, and sucrose on senescence patterns. Two 2,4-D resistant biotypes, B6 and B9, displayed RR to 2,4-D. Plants were treated with 2,4-D ranging from 0 to 11,520 g ai ha^{-1} at three developmental stages: 2-4, 6-8, and >10 expanded leaves. The resistance level increases with the growth stage, as indicated by ED_{50} values from 9.4 and 6.4 at Growth Stage 1 to 10.9 and 3.3 at Growth Stage 3, respectively. Both resistant biotypes exhibited RR, with a reduction in photosynthesis (60 to 94%), an increased transpiration rate (91 to 122%), and a 42 to 45% decline in chlorophyll fluorescence (Fv/Fm) within 3 hours after treatment compared to nontreated. Exposure to 2% w/v sucrose in a hydroponic solution decreased leaf chlorophyll content by 25% compared to the control. Conversely, cytokinin treatment did not have any significant effect, although a trend in RR reduction was observed. The results support that the resistant factor increases with the developmental stage and that changes in the physiological aspects of the plant happen within minutes of exposure. This response seems to be energy-dependent as sucrose promotes RR.

Nozzle Angle and Orientation Considerations for Targeted Spray Applications. Jeffrey Golus*[1], Aleksandra Pantic[2], Gabriel de Souza Lemes[2], Milos Zaric[1]; [1]University of Nebraska - Lincoln, North Platte, NE, [2]University of Nebraska, North Platte, NE (14) (014)

Weed management has long encountered challenges, including new crops, weed species migration, herbicide resistance and regulatory and economic influences. Spot spraying is a recent technological development to address some of these factors, especially the economic perspective. Some of these systems utilize a rearward nozzle angle orientation to increase the time interval from detection to application, to increase accuracy of computing decisions. However, the impact of this back angle in delivering the correct dose may not be fully understood. This study aims to explore the impact of nozzle spray angle and orientation of the nozzle through spray pattern dimensions and uniformity. Evaluated were stainless steel TP3003, TPU4003, TPU6503 and TPU8003 nozzles in both broadcast and banding (even) versions; and evaluated at rearward angles of 0 (vertical), 15 and 30 degrees. To achieve a 38.1 cm application width, the appropriate boom height was calculated for each nozzle angle. Treatments were applied in a spray chamber at a speed of 3.54 m s^{-1} and nozzle pressure of 276 kPa; with spray solution consisting of water and 3 g L^{-1} blue dye. Kromekote paper of 21.6 x 28.0 cm was placed on the spray chamber shelf and after application was removed and allowed to dry. A flatbed scanner was then used to scan paper at 31.5 dots mm^{-1} (800 dots $inch^{-1}$). These images were then analyzed to quantify spray coverage. Analysis showed as rearward angle increased, spray pattern width also increased, resulting in increased coverage outside the 38.1 cm target width. This implies a lower coverage within the target area and thus a reduced dose of the herbicide reaching the detected target. Understanding the impact and implications of nozzle selection and orientation is critical to the success of any targeted spray system, to deliver the desired dose to the target.

Potential Impacts of Transgenerational Memory from Weed Competition on Spring Wheat.
Albert O. Kwarteng*; University of Idaho, Moscow, ID (015)

Competitiveness is a key trait for plants to grow and survive abiotic and biotic stresses. Studies have shown that plants can store and recollect memories of past stress events which may affect their response to future stress. This study evaluated how multigenerational weed exposure affects phenotypic plasticity of spring wheat (*Triticum aestivum*). Wheat was planted in the center of 3L plastic pots surrounded by either 8 kochia (*Bassia scoparia*), 8 Italian ryegrass (*Lolium multiflorum*), 8 wheat, or no surrounding plants in a completely randomized design with 15 replications. Seeds harvested from the first generation were used to plant the second generation, and the process was repeated under the same conditions to obtain the second, third, fourth, and fifth generations. The original seed and seeds from the five generations were grown in the greenhouse at the same time in a factorial common garden experiment. Wheat-wheat competition was the treatment with the most significant impact on yield and biomass reduction, and ryegrass competition reduced wheat biomass and yield compared to kochia competition. Wheat-only treatment produced more tillers, spikes, and yield in all generations, but peaked in the 3rd or 4th generation, where the number of seeds per plant in generation 3 was three times that of generation 1. These suggest a potential maladaptive impact of transgenerational memory of weed stress on wheat. The transcriptomic and epigenomic data, together with data from the quantification of gene expression would provide a better understanding of the mechanisms involved in these observations.

Elevated Temperature Impact on Grass and Broad Leaf Weeds. Amna Dar*, Swati Shrestha, Amarnadh Oleti; Oklahoma State University, Stillwater, OK (016)

Steady increase in temperature due to global warming can significantly impact weed growth. The study investigates response of Foxtail (grass weed) and Palmer (broadleaf weed) to increasing temperature conditions. Treatments included growing these weeds in three temperature-controlled growth chambers: control/ambient condition ($60/55^0$ F day/night), moderately elevated ($63/58^0$ F) and elevated ($66/61^0$ F). Temperature in the growth chambers were adjusted monthly to simulate natural temperature rise from April to June alongside their respective treatments. Different plant parameters recorded were days to germination, number of tillers/leaves, days to first inflorescence, chlorophyll content, biomass, and yield. One-way ANOVA indicated a significant temperature impact on all the parameters assessed except biomass (for both weeds) and yield for Palmer ($p<0.05$). Average days to germination were lowest under elevated temperature (8 days for Foxtail and 11 days for Palmer) as compared to control (10 days for Foxtail and 18 days for Palmer). By week five, Foxtail exhibited notably greater tiller numbers under elevated temperature compared to control, similar trend was noticed with the number of Palmer leaves. Average chlorophyll content was highest under elevated temperature condition upto week six and started decreasing after that for both weeds. The average yield of Foxtail under elevated, moderately elevated, and control temperatures were 7.55, 2.69, and 0.88 gms, respectively. Even though not significant, yield of Palmer was highest under elevated temperature (14.7 gm). These findings suggest increased competitiveness of weeds in warmer conditions. In the future, scientists should consider temperatures' impact on weed growth while developing weed management practices.

Herbicide Resistance Within Oregon's Perennial Horticulture Crops: New Cases of Pendimethalin, Glufosinate, and ALS Resistance. Leah N. Mowery*, Marcelo L. Moretti, Joshua W. Miranda; Oregon State University, Corvallis, OR (017)

Ever-evolving cases of herbicide resistance in agricultural systems demand continuous surveillance and adaptive strategies. In Oregon's Willamette Valley, accessions of Italian ryegrass (*Lolium perenne* spp. *multiflorum*), soft brome (*Bromus hordeaceus*), and wild carrot (*Daucus carota*) were gathered from perennial crop systems due to suspected resistance to pendimethalin, glufosinate, and flazasulfuron herbicides, respectively. Whole-plant dose-response experiments for pendimethalin resistance were conducted using Willamette-series soil with ten seeds of Italian ryegrass. For glufosinate and flazasulfuron, one soft brome plant at the 2-3 tillers growth stage and one wild carrot plant at the four true-leaves growth stage were used, respectively. Pendimethalin resistance was confirmed in the putative-resistant accession of Italian ryegrass, exhibiting tolerance 2.6 times higher than the susceptible accession (LD_{50} 572 g ai ha^{-1}), with plant survival observed up to 17,600 g ai ha^{-1}, 2.6 times the field rate. Glufosinate resistance was confirmed in two putative-resistant accessions of soft brome, with resistance levels ranging from 2.2 to 2.3 compared to the susceptible accession (GR_{50} 108 g ai ha^{-1}). Flazasulfuron resistance was also confirmed in the putative-resistant accession of wild carrot, exhibiting resistance levels 4,493 times higher than the susceptible accession (GR_{50} 16.62 g ai ha^{-1}). This marks the first case of pendimethalin resistance in Italian ryegrass, the first documented case of resistance to any herbicide in soft brome, and the first case of ALS-inhibiting herbicide resistance in wild carrots.

Future research will delve into understanding the genetic and physiological basis of these resistances, essential for devising effective management practices.

Germination of Common Lambsquarters (*Chenopodium album*) Seeds in Response to Nitrate and Far-red Light. Jonah Zubil Ziyaaba*, Andrew R. Kniss; University of Wyoming, Laramie, WY (18) (018)

Common lambsquarters is a troublesome weed, in part, because it forms persistent seed banks. Seed germination is often suppressed under low red to far-red light ratios (R:FR) and low intensity sunlight present under plant canopies. This promotes germination in high R:FR, indicative of less competitive environments. High soil nitrate concentration also stimulates seed germination in some species. It is unclear how these combined environmental signals (R:FR and nitrate) impact germination patterns of common lambsquarters. Laboratory studies were conducted to quantify germination of six common lambsquarters accessions in response to nitrate and light in a factorial completely randomized design with three replicates. Thirty seeds of each accession were placed in petri dishes treated with four nitrate concentrations ranging from 0.0 mM to 50.0 mM. Three light environments included very low fluence (VLF) of white light (0.007-0.094 µmol m^{-2} s^{-}), low fluence of red (R-LF) light (157-184 µmol m^{-2} s^{-}), and high irradiance of far-red (FR-HI) light (29-32 µmol m^{-2} s^{-}), each applied in a 16 hr photoperiod. Daily germination was analyzed using a three-parameter log-logistic regression model. Germination reached 60 to 100% under R-LF depending on the accession. Accessions responded differently to light environments, with one accession reaching >80% germination regardless of light environment, while most accessions showed substantially reduced germination under FR-HI. For most accessions, germination was greater in both VLF and R-LF when nitrate concentration increased, but nitrate had no effect in the FR-HI light environment. These results suggest that common lambsquarters accessions interact differently with nitrate and light.

Modeling Germinability of Annual Bluegrass in Grass Seed Production Systems. Clint M. Mattox*; USDA-ARS, Corvallis, OR (019)

Timing weed management interventions to control and further limit annual bluegrass (*Poa annua* L.) seed contributing to the seed bank can be imprecise because panicles are observed most of the year in western Oregon. If growers could predict when annual bluegrass seed becomes viable on the plant, timing of herbicide applications or mechanical weed control could be improved. Previous research in eastern North America suggests that annual bluegrass germinability can be predicted using growing degree day (GDD) modeling; however, no data west of the Mississippi or from a climate like western Oregon exists to date. To elucidate this question, a randomized complete block design field experiment replicated four times took place in a grass seed production field of tall fescue (*Festuca arundinaceae*) that was established in October 2022. Growing degree days were calculated using a base temperature of 0 Celsius starting on 01 January 2023 using data from an onsite weather station. Annual bluegrass panicles were collected based on 50 GDD increments, dried at 36 Celsius for at least 7 days, screened using a 1.8 mm round screen, and stored at 4 Celsius for at least 7 days. A subsample up to 400 seeds per plot were placed on moist blotter paper, randomly assigned a location in an incubator with a setting of 25:20°C and 8:16 hours light:dark cycle, and germination was assessed twice a week for 21 days. First year results suggest

that germinability of annual bluegrass seed increased as growing degree days accumulated up to approximately 350 GDDs.

Basis for Dicamba Resistance in Palmer Amaranth (*Amaranthus palmeri*). Dustin Abdiel Moreno*[1], Raphael M. Garrido[2], Larry Steckel[3], Sofia Marques-hill[4], Sarah Morran[1], Todd A. Gaines[1], Franck E. Dayan[1]; [1]Colorado State University, Fort Collins, CO, [2]São Paulo State University, Assis, Brazil, [3]University of Tennessee, Jackson, TN, [4]Colorado State University - Agricultural Biology, Fort Collins, CO (020)

Amaranthus palmeri (*Palmer amaranth*) has become one of the most troublesome weeds in the USA, evolving resistance to several herbicide groups and causing a significant reduction of crop yields due to its high competition capacity. A survey conducted in 2021 in Tennessee cotton and soybean fields found a low control of Palmer amaranth by dicamba or 2,4-D (Group 4 herbicides). A well-known sensitive population from Arizona (sensitive) was incorporated as a control. Liquid Chromatography-Mass Spectrometry (LC-MS/MS) analyses were conducted on resistance and sensitive accessions to test whether metabolism was involved, using two metabolic inhibitors: malathion to inhibit cytochrome P450 monooxygenases and 4-chloro-7-nitrobenzofurazan to inhibit glutathione S-transferases that are documented to participate in herbicide detoxification. One accession from Lauderdale County (resistant) was highly resistant to dicamba, achieving a visual injury of 390±43 g ae/ha, relative to 69±9 g ae/ha in the sensitive biotype. However, plants are even more resistant than this since many individuals from the Lauderdale accession survive the highest dicamba rate and recover over time. This biotype was not cross-resistant to 2,4-D. The rate of metabolic degradation of dicamba in the resistant and sensitive biotypes was similar, suggesting that metabolism-based detoxification of dicamba does not contribute to resistance in the Lauderdale population. This suggests that a target site mutation may be involved in conferring high resistance. Hence, total RNA from resistant and sensitive plants was isolated from the control and treated (280 g/ha dicamba) and then submitted for sequencing and analysis. We are in the process of analyzing this data.

Understanding the Molecular Mechanism of a Novel Transcription Factor Imparting Non-target-site Resistance to Quizalofop in Rice. Srishti Gupta*; Colorado state University, Fort Collins, CO (021)

Chemical mutagenesis using sodium azide was performed to develop quizalofop-p ethyl (QPE) resistant rice lines. One of the lines (TSR) had a target-site mutation in acetyl-CoA carboxylase. On the other hand, the NTSR line had a novel mutation imparting non-target-site resistance to group 1 herbicide. Genetic mapping identified a single nucleotide polymorphism in an uncharacterized putative zinc finger transcription factor. Transcription factors (TF) play an important role in many biological processes like cell growth, division, and response to abiotic factors, but no mutation in TFs has been associated with herbicide resistance to date. The objective of this research is to understand the molecular mechanism through which a mutation in a transcription factor imparts herbicide resistance. The degree of resistance of TSR and NTSR was assessed with dose-response curve experiments using QPE, relative to a wild-type rice line. The rate of QPE metabolism was measured to determine the basis of resistance in wild-type (WT) rice, NTSR rice and TSR rice collected 1, 2, 4 and 8 days after treatment using LC-MS/MS analysis.

Putative NTSR genes that may be regulated by the mutated transcription factor and contribute to herbicide resistance were investigated using RNA Seq analysis. Glutathione-*S*-transferase (GSTs) and cytochrome P450 monooxygenases (Cyps) genes were more highly expressed in mutated NTSR and double mutant (TSR+NTSR) than in WT rice. Malathion and NBD, metabolic inhibitors of P450s and GSTs respectively when sprayed on WT, NTSR showed reduced metabolism and more injury symptoms as compared to the ones treated with QPE only. Greenhouse assays, the NSTR and TSR lines were 1.9 and 2.4 more resistant to QPE than the WT. On the other hand, a TSR/NTSR double mutant line was 6.8 times more resistant to QPE than WT. Computational studies performed to delineate the role of mutation produces a stable protein-DNA complex with the DNA strand interacting with positively charged amino acids arginine and lysine in the binding domain.

WSWS PROJECT 1: WEEDS OF RANGE, FORESTRY, AND NATURAL AREAS

Improving Rangeland Sustainability Through Novel Downy Brome Management Tactics. Erin B. Teichroew*, Jane Mangold, Lilly L. Sencenbaugh, Lisa J. Rew; Montana State University, Bozeman, MT (090)

Sustainable rangelands can support environmental, social, and economic goals of ranchers and resource managers in the Intermountain West. A key challenge in maintaining sustainable rangelands is managing non-native species. Effective management tools for downy brome (*Bromus tectorum* L.) are desired by many managers and producers. Currently most rely on herbicides but effective alternatives to manage downy brome are needed. We tested two novel downy brome management methods, biofumigant and soil amendment, and compared them to herbicide and non-management options. Five trials were established at three locations in southwestern Montana. Seven treatments were applied: a non-treated control, two levels of biofumigant (mustard seed meal), three levels of soil amendment (Nutrafix), and one level of herbicide (indaziflam). We analyzed the impacts of the treatments on the biomass of downy brome, perennial grasses, and forbs over three years. We found downy brome biomass was reduced the first year after application by most treatments but returned to pre-treatment levels three years post application in all treatments. Biomass of perennial grasses was highest in the indaziflam plots. Forb biomass was not affected by any of the treatments. These results indicate that our treatments may be effective for short term management, but since downy brome biomass returned to pre-treatment levels three years post treatment multiple applications may be needed for long term control. There were no trends seen in the desired community, except for increased perennial grass biomass in the indaziflam treatment.

Evaluating Differences in the Ecology of Small, Non-native Annual Mustards and the Need for Management in Grasslands. Lisa J. Rew*, Jordan Meyer-Morey, Matthew Lavin; Montana State University, Bozeman, MT (091)

Three alyssum species (*Alyssum alyssoides, A. desertorum* and *A. simplex*) are found in disturbed land within the sagebrush biome and other areas of the west. The species are difficult to distinguish

among without a hand-lens and ecological information is scant. We used herbarium data to evaluate for differences in climate niches, assessed seed germination over a temperature gradient (5 - 40 ^{O}C), and their competitive ability with each other and a non-native annual grass. The species overlap in most climate variables but *A. alyssoides* prefers higher precipitation and lower elevation sites than the other two species. All three species had good germination, but *A. desertorum* had the narrowest temperature range, the other two species were similar. All were weak competitors to the non-native grass. So, what is their role in the ecosystem? Non-native plants can reduce biodiversity and disrupt essential ecosystem services and functions. For most non-native plant species however, quantitative evidence of negative effects is lacking. To address this, we recorded vegetation at six sites along an elevation gradient within lightly disturbed mountain sagebrush (*Artemisia tridentata* ssp. *vaseyana*) habitats, within Yellowstone National Park. We observed *A. desertorum* at four and *A. simplex* at two sites, no *A. alyssoides* was found. The presence of either *Alyssum* species did not affect species richness nor Shannon's diversity, and functionally similar native annual forbs were not displaced in invaded areas. Our study suggests that while there are subtle differences in these species' ecology they are relatively weak competitors within the mountain sagebrush steppe.

Effects of Grazing Deferment Following Invasive Annual Grass Control with Indaziflam in Northeast Wyoming. Walker T. Billings*[1], Brian A. Mealor[2]; [1]University of Wyoming Department of Plant Science, Sheridan, WY, [2]University of Wyoming Sheridan Research and Extension Center, Laramie, WY (092)

Annual grasses native to Mediterranean Europe, such as cheatgrass (Bromus tectorum) and ventenata (Ventenata dubia), have invaded Western North America, displacing native species and causing severe impacts to rangeland ecosystems. Ventenata was first confirmed in northeast Wyoming in 2016 and is expected to be an extremely competitive weed in the Great Plains ecoregion. Indaziflam is a cellulose biosynthesis inhibitor herbicide labeled for annual grass control with long-term soil activity. Management recommendations from some government agencies include grazing deferment for one to multiple growing seasons following indaziflam application to promote regeneration of perennial plant communities. We focused on understanding the effects of grazing exclusion following indaziflam application on plant communities across two ecological sites at four locations in northeast Wyoming. Sites were treated with 123 g ai ha-1 indaziflam applied in 18.9 L ha-1 from a helicopter in 2019. At each site, we excluded livestock grazing using electric fencing during the growing season and allowed ambient grazing in adjacent, paired plots. We collected plant community data via ocular cover estimates and line point intercept from 2019-2023. We analyzed vegetation data by comparing various linear and nonlinear regression functions and performed goodness of fit and Akaike information criterion tests to evaluate optimum models to describe the data. Neither grazing nor ecological site influenced invasive annual grass cover following indaziflam application. Perennial grass response over time was influenced by ecological site, but not by grazing, suggesting that grazing exclusion may not be necessary to meet vegetation goals.

The Effects of Invasive Annual Grass Control on Shrub Leader Growth and Mule Deer (*Odocoileus hemionus*) Visitation in Boulder County, CO US. Jacob Courkamp*[1], James

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Invasive annual grasses like downy brome (*Bromus tectorum* L.) have invaded vast expanses of semi-arid rangeland in western North America, challenging the persistence of native plant communities that provide important habitat for wildlife. For example, declining mule deer (*Odocoileus hemionus*) populations have been linked to habitat losses driven by the frequent and repeated wildfires that typically follow annual grass invasion. The competitive effects of invasive annual grasses may also reduce the growth and production of co-occurring shrubs that provide forage for mule deer in the form of woody browse; new shrub leaders are a particularly important source of winter forage due to their increased nutritional content compared to older growth. We measured the effects of downy brome management on forage shrub leader growth and mule deer habitat use at the Hall Ranch Open Space (Hall Ranch) in Boulder County, Colorado from 2018-2023. Operational-scale herbicide treatments (2.5-6 ha) intended to control downy brome occurred at three sites (treatment plots) at Hall Ranch in January and February 2018, and each treatment was paired with a nearby untreated check of similar size (control plots). Treatment and control plots were located in areas featuring abundant downy brome and co-occurring native shrubs when the study was initiated. Treatment nearly eliminated downy brome and increased the mean length of the longest leaders harvested from shrubs in treatment plots. In the later years of the study (2021-2023), motion-activated camera traps were used to compare monthly mule deer visitation (percentage of days deer were photographed) and monthly counts of mule deer foraging observations in treatment and control plots. Herbicide treatment and subsequent cheatgrass control increased mule deer visitation and foraging observations in treatment plots, particularly during winter months when nutritious forage is scarce and mule deer rely on woody browse. Our results suggest that invasive annual grass control may substantially increase the availability of nutritious woody browse for mule deer during winter months, and effective annual grass treatment may represent a highly effective strategy for improving mule deer habitat in areas where invaded plant communities continue to support important woody browse species.

Impacts of Herbicide, and Macro- and Micro-nutrients on Non-native Annual Grass, Ventenata, and Desired Species Composition in Montana Rangelands. Lilly L. Sencenbaugh*, Lisa J. Rew, Jane Mangold; Montana State University, Bozeman, MT (094)

As average temperatures increase and precipitation patterns shift, more Montana rangelands may become suitable for the non-native annual grass ventenata (*Ventenata dubia* (Leers) Coss). Ventenata has unreliable forage quality which is a problem for hay and cattle producers. These factors necessitate an improved understanding of effective management strategies for this species. We sought to quantify the response of ventenata and desired forage grasses to (1) integrated management and (2) climate and herbicide treatments. Our integrated management study combined herbicide treatments (flufenacet+metribuzin, indaziflam, indaziflam+imazapic, and non-sprayed) and macro- and micro-nutrient fertilizers (NPK, Nutrafix™, and no fertilizer), as a full factorial, split-plot design, at three rangeland sites across Montana. Our herbicide treatments effectively reduced ventenata cover ($p<0.01$), but herbicides and fertilizers had no effect on desired forage one year after application. In our second study, we quantified ventenata and desired grass responses to varying climatic conditions using open top chambers and rainout shelters (warmer,

warmer+drier, and ambient) and herbicide (indaziflam, non-sprayed) as a full factorial design. Ventenata cover was lower in the warmer ($p=0.02$) and warmer+drier ($p<0.01$) versus ambient control treatments; herbicide reduced ventenata in both the ambient and warmer ($p<0.01$ both) treatments, but there was no difference in warmer+drier ($p=0.20$) because the ventenata cover was nearly 0 following the climate treatment. Perennial grass cover did not vary among climate and herbicide treatments. Further monitoring of these sites will provide additional insight into effective integrated management practices for ventenata under a changing climate.

Long-Term Resilience of Sagebrush Steppe Plant Communities to Annual Grass Control. Lisa C. Jones*[1], Georgia R. Harrison[2], Timothy S. Prather[1]; [1]University of Idaho, Moscow, ID, [2]Plant Sciences, University of Idaho, Moscow, ID (095)

Invasive annual grasses negatively impact sagebrush steppe by decreasing native plant diversity and shortening fire return intervals. Indaziflam, a longer residual herbicide, effectively controls annual grasses yet there is concern that it can impede recruitment from the seed bank. We explored large-scale aerial applications of indaziflam and indaziflam + imazapic (70 and 84 g/ha, respectively), which had a soil-surface droplet coverage ranging from 2-21%. Applications occurred in a mid-elevation mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*)-dominated pasture near Hailey, ID in fall 2019 (pre-emergent). We monitored vegetation composition annually for four years post-treatment. Four years post-treatment (2023), control of *Bromus tectorum and B. japonicus* was higher from the indaziflam + imazapic treatments (mean 89%) compared to indaziflam alone (mean 78%). Control from indaziflam increased as herbicide droplet coverage increased, though there was no relationship between control and droplet coverage for indaziflam + imazapic, likely because imazapic has greater mobility in the soil than indaziflam. In 2023, deep-rooted native perennial grass cover increased as herbicide droplet coverage increased, suggesting release from competition. Sandberg bluegrass (*Poa secunda*) cover increased with increasing droplet coverage, but only in plots treated with indaziflam alone, suggesting lasting injury from imazapic. Native perennial forb cover was highest in treated plots (mean 64%) compared to nontreated plots (mean 45%), and did not differ among herbicide treatments. Native annual forb cover did not differ between treated and nontreated plots, nor did herbicide droplet coverage affect cover. Among all plots, cover of native perennial grasses and forbs preferred as forage by greater sage grouse decreased with increasing annual grass cover. While the number of native plant species did not differ between treated and nontreated plots, sum foliar cover of native plants was higher in treated plots compared to nontreated plots, indicating desirable species responded favorably to annual grass control. Among treated plots, sum cover of native plants increased with increasing herbicide droplet coverage. In 2023, we observed recruitment from the seedbank of 46 native plant species, and the amount of native plant recruitment did not differ between treated and nontreated plots. Notably, recruited plants included 32 forb species that are preferred forage of greater sage grouse. Overall, four years post-treatment of this relatively intact and mesic sagebrush system, we observed good control of annual grasses and greater native plant cover with no harm to natural recruitment from the resident seedbank.

Long-Term Effects of Indaziflam Applications on a Healthy, Diverse Landscape in Northern Utah. Weston Maughan*[1], Hailey L. Buell[2], Mirella F. Ortiz[2], Eric P. Westra[2], Thomas Monaco[3],

Corey V. Ransom[2]; [1]Washington State University, Pullman, WA, [2]Utah State University, Logan, UT, [3]United States Department of Agriculture, Logan, UT (126)

In recent years, indaziflam has been widely studied as a potential solution for the ever-growing threat of invasive annual grasses in the Western US. While these studies have demonstrated the effectiveness of the herbicide, relatively few of them have followed the herbicide until the end of its 3-5 years of soil persistence. This knowledge gap has led to concerns for possibly unconsidered, long-term side effects. To determine the long-term environmental effects of indaziflam applications, a randomized complete block design experiment with ten different herbicide treatments, including indaziflam, was applied to a healthy, diverse landscape with a mild downy brome (*Bromus tectorum*) infestation. Transect lines were used annually for five years following herbicide application to measure the percent coverage of different species found in each plot. This data was used to determine the impact of different herbicide treatments on the cover of key species and landscape functional groups, diversity, evenness, richness, etc. These studies found that plots treated with indaziflam, or indaziflam-inclusive mixtures, were able to effectively eliminate downy brome without reducing cover associated with desirable perennial forbs and naturalized grasses. While this study did find a correlation between indaziflam applications and decreases in total plant richness and diversity, those changes were explained by the significant decreases in downy brome cover, invasive richness, and minimal to no significant negative effects on desirable richness in those same treatments. The study concluded that, when applied to healthy, diverse landscapes, indaziflam effectively controlled invasive annual grasses, while maintaining desirable species cover and richness.

Twenty Years of the Snake River Project: an EDRR Success Story. Lesley Coats Beckworth*, Erika Edmiston, Mark Daluge; Teton County Weed & Pest, Jackson, WY (127)

The Snake River Project, an Early Detection and Rapid Response (EDRR) program aimed at located, removing, and eradicating *Tamarix spp*., *Lepidium latifolium*, and other high priority species, was launched by the Jackson Hole Weed Management Association (JHWMA) in 2003 after *Tamarix spp.* was identified on the Upper Snake River. The JHWMA and Teton County Weed and Pest District (TCWP) have conducted annual monitoring for invasive plants along 80 miles of river from the Jackson Lake Dam to Palisades Reservoir. Through 17 years of this project, crews located 408 individual points of EDRR species. While invasive plants have been eradicated at 146 locationsin the project area, these crews rarely locate *Tamarix spp.* and find nearly a dozen new locations of *L. latifolium* plants each year indicating that there is a seed source that is being missed. In 2019, the JHWMA contracted Working Dogs for Conservation (WD4C) to scent training canine teams for these species. Over the last four years canine and handler teams found an additional 132 *L. latifolium* locations on the Snake River and Gros Ventre River, roughly 40% more than human teams. In 2023, canine and handler teams located a large stand of *L. latifolium* with no additional points upstream, indicating that the seed source may have been identified. Canine teams also improved other aspects of the Snake River Project including expansion of partnerships and increasing public interest in invasive species management.

Management of Potential Wildfire Ladder Fuels in Western U.S. Forests. William L. Hatler*[1], Byron B. Sleugh[2], Craig M. Alford[3], Jodie A. Crose[4]; [1]Corteva Agriscience, Meridian, ID,

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Wildfire frequency and intensity is increasing in western U.S. forests. Mismanagement or non-management of brushy understory (ladder fuels) is one of the contributing factors. There is growing interest in the western vegetation management industry for prescriptive, grass-safe ladder fuel management programs for creation of shaded fuel breaks. Shaded fuel breaks are corridors with widely spaced trees in which the small trees and undergrowth have been cleared, leaving herbaceous cover for soil stability. Three trials were established in 2022 to test the efficacy and herbaceous plant tolerance of multiple herbicide tank mixes on common ladder fuel species in California forests. Testing included individual plant treatments with aminopyralid (2 lb ae/gal) at 1% volume per volume (v/v) + triclopyr butoxyethyl-ester or triclopyr choline (4 lb ae/gal) at 2% v/v, aminopyralid 1% v/v + triclopyr choline 2% v/v + 2,4-D choline (3.8 lb ae/gal) at 1% v/v, aminopyralid + florpyrauxifen-benzyl WDG (0.71 + 0.06 lb ai/lb) at 1.05 g product/L + triclopyr choline 2% v/v + 2,4-D choline 1% v/v, and fluroxypyr (2.8 lb ae/gal) at 1% v/v + triclopyr choline 2% v/v. Woody species targeted were *Castanopsis chrysophylla, Arctostaphylos patula, Ceanothus prostratus, Ribes uva-crispa, Ceanothus velutinus, Prunus emarginata,* and *Symphoricarpos albus*. All treatments achieved a decrease in woody plant cover (potential ladder fuel load) at 1 YAA, ranging from 16-33% compared to the untreated at 61%. Herbaceous plant cover in the season of application and at 1 YAA was not decreased in any treatment versus the untreated. Results support including targeted woody plant treatments with selective herbicides in shaded fuel break establishment and management programs.

Forb Response to Florpyrauxifen-benzyl, Aminopyralid, and Clopyralid for Use in Natural Areas. Jodie A. Crose*[1], William L. Hatler[2]; [1]Corteva Agriscience, Claremore, OK, [2]Corteva Agriscience, Meridian, ID (129)

A growing need exists to improve our understanding of herbicide tolerant native species to preserve our diverse prairie and rangeland systems. Encroachment of weedy or invasive species results in competition for resources, which ultimately may lead to a reduction in native plant populations. Controlling these undesirable species in a matrix of diversity is difficult, however herbicides remain the most efficient tool to do so. Previous work with aminopyralid evaluated 90 forb species, 71 of which recovered by 2 YAA. In 2023, we evaluated native species injury and presence following applications of two rates of aminopyralid (88 and 123 g ae Ha-1), florpyauxifen-benzyl (27 g ai Ha-1), clopyralid (263 g ae Ha-1), and two rates of a premix of florpyrauxifen-benzyl + aminopyralid (96 and 129 g ae Ha-1) at four different locations. At two sites, 1 MAA, injury (32%) was lowest across all species following an application of clopyralid. Florpyrauxifen-benzyl injury was similar at 45%. Similar injury was observed from all other products with both the lower rates of aminopyralid and the premix of aminopyralid + florpyrauxifen-benzyl averaging 52% and 54%, respectively. The higher rates of these two treatments both averaged 58%. At the other two sites, 2 MAA, injury was similar across all species ranging from 37% with clopyralid to 48% with the high rate of aminopyralid. Species population response will be monitored this year to better understand how these applications affect the plant community.

Better Together? Remote Detection of Invasive Annual Grass Species as Groups vs Single Species Models. Chloe M. Mattilio*[1], Brian A. Mealor[2], Jaycie N. Arndt[3]; [1]University of Wyoming, Sheridan, WY, [2]University of Wyoming Sheridan Research and Extension Center, Laramie, WY, [3]University of Wyoming, Arvada, WY (144)

Remote sensing allows for landscape-scale monitoring of invasive annual grasses by capitalizing on phenological differences to distinguish invasive species from natives. We evaluated the ability of frequently-collected multispectral imagery (blue, green, red, near infrared, and derived spectral indices) to detect invasive annual grass (IAG) species in a mixed-grass prairie in Sheridan County, Wyoming. Imagery was collected weekly from May - July of 2021- 2023 at 5m x 5m spatial resolution. Research questions were: 1) How do invasive annual grass species differ phenologically in multiple years of imagery? 2) How does grouping phenologically-different invasive annual grass species influence remote detection rates? We used repeated ground mapping of vegetation cover to train three dense cover classification models: One for ventenata *(Ventenata dubia)*, one for combined, phenologically similar ventenata, medusahead (*Taeniatherum caput-medusae*), and Japanese brome (*Bromus japonicus*), and one for all IAGs (ventenata, medusahead, Japanese brome, and cheatgrass (*Bromus tectorum))*. Reflectance and indices were extracted at training locations where there was >25% target IAG canopy and low canopy cover of perennial grasses and these patterns were plotted through the season. Four time sets of data were evaluated: Full season, early season, midseason and a single date for each year. Ventenata was best represented in training data and by classification models built on full season imagery. The phenologically-similar species group outperformed a combined model predicting all IAG species. Full season imagery sets, and specifically imagery from 2021, produced the most accurate invasive annual grass prediction models.

Harnessing Digital Technologies to Advance Invasive Annual Grass Management. Shannon Clark[1], Derek Sebastian*[2], Craig Hossfeld[1,] Miranda Mueller[3], Mitchell Stephenson[4]; [1]Envu, Sheridan, WY, [2]Envu, Greeley, CO, [3]University of Nebraska-Lincoln, Lincoln, NE, [4]University of Nebraska-Lincoln, Scottsbluff, NE (145)

Downy brome (*Bromus tectorum* L.) threatens rangeland biodiversity and productivity throughout the western US. Focusing efforts on managing downy brome in intact rangelands can have immediate impacts to forage productivity and quality. We conducted a study to evaluate desirable forage response to downy brome treatments in the Nebraska Panhandle. Plots (1 to 3 ha) were established at five sites surrounding Scottsbluff, NE. Applications were made with a fixed wing aircraft at 47 L ha^{-1} with medium droplets (~300 microns) in September 2022. Treatments included indaziflam 73 g ai ha^{-1} + imazapic 69 g ai ha^{-1} and a paired non-treated control at each site. At each site, biomass was collected from 9 paired quadrats placed randomly within the treated and non-treated plots. Plant material from three of the quadrats at each site was analyzed for forage quality and mineral content. At 10 MAT, perennial grass biomass increased from 463 kg ha^{-1} in the non-treated control plots to 1915 kg ha^{-1} in the treated plots. Crude protein increased from 5.9% in forage from downy brome infested plots to 9.6% in forage from the treated plots, while total digestible nutrients increased from 50.1% in the non-treated plots to 55.1% in the treated plots. Forage from treated plots also had 130% to 160% higher calcium, phosphorous, potassium, iron, and boron content. Acid detergent fiber and neutral detergent fiber were significantly decreased in

forage from treated plots. High resolution satellite imagery was then used to remotely identify downy brome infestation at the sites and results were compared to data collected on-the-ground. This work demonstrates that for livestock producers, downy brome infestations not only have a significant impact on perennial forage production but also on forage quality which can impact herd health and gains. Digital technologies such as satellite imagery can be utilized to identify annual grass invasions, plan treatments, and monitor treatment effectiveness. These digital technologies can advance annual grass management in terms of herbicide and labor savings.

Lichen and Moss Response to Cheatgrass Control with Indaziflam and Fire. James Sebastian*; Boulder County Open Space, Longmont, CO (146)

Boulder County Open Space (BCPOS) manages properties that include high plains, foothill's shrub steppe, and mountain ecosystems in Colorado. These properties provide critical wildlife and pollinator habitat within highly diverse ecosystems. Of major concern is the loss of critical wildlife habitat, diversity of native plants, and specialized ecosystems, due to cheatgrass and cheatgrass fueled wildfires. Invasive winter annual grasses, such as cheatgrass (Bromus tectorum L. and Bromus japonicus) are considered serious threats to regional biodiversity. There are 781 lichen species that have been reported in Colorado alone; however, these species tend to be overlooked in monitoring programs. Both lichens and moss add biodiversity on a landscape scale. Little is known about the impacts cheatgrass or wildfires have on these species. Biological soil crusts (biocrusts) living on the soil surface and lichens and moss living on rock, shrubs, trees, and decaying plants are a critical component of dryland communities that prevent soil erosion, cycle nutrients, and biotic resistance to annual grass invasion. Past research conducted across the Western US has shown that degradation or the loss of biocrusts is strongly correlated to increased cheatgrass invasion and eventual transition from native shrublands and perennial grasslands to annual grasslands dominated by invasive species. Rejuvra (Indaziflam from Envu), has multi-year effects of reducing annual grasses, which makes Rejuvra a promising herbicide for conservation purposes with little disturbance to biocrusts. We found that Rejuvra did not injure lichens or moss on soil or rock at sites that were sprayed 1 to 7 years after treatment. In most cases lichens and moss density, cover, and growth increased compared to adjacent dense cheatgrass infested (>40% canopy cover) burned or non-burned sites. Our findings show that altered fire regimes can have severe and long-persisting negative effects on lichen and moss communities. The high plains, foothill's shrub steppe, and mountain ecosystems in Colorado we studied have largely shifted from a historical fire regime characterized by low frequency and low-severity fire prior to cheatgrass invasion, to a contemporary fire regime characterized by frequent and high intensity fires due to cheatgrass fine-fuels. The size of high severity burn patches in this study system has increased in recent decades along the Front Range of Colorado. In Colorado, 15 of the 20 largest wildfires have occurred in the past 11 years. Four of the top 5 largest wildfires occurred in the past 6 years. Although low-severity fire—which historically typified this ecosystem—has little to no effect on lichen diversity, lichen richness drops off precipitously in areas that burned at high severity. Lichen and moss density, cover, and diameter increased in burned and unburned sites where dense cheatgrass (>40% canopy cover) and cheatgrass thatch (>1/4" thick) was removed after Rejuvra treatments. This re-enforces our hypothesis that low severity burns have less impact on lichens and moss living as biocrust on the soil surface and on rock, and decreasing lichen diversity with

increasing fire severity. Preliminary flammability research conducted in Idaho assessing temperature, flame length, and mass consumption has shown that cheatgrass sustained high ignitability and mass consumption through the entire growing season even at the highest moisture levels. The addition of cheatgrass to perennial grass increased perennial grass flammability. High-severity fire appears to affect lichens both directly, by consuming them, and indirectly, by reducing canopy cover, removal of shrubs that create cool, moist microclimates, and the re-invasion of cheatgrass after fire disturbance. In fact, sites that burned at the highest severity, with approximately 90%– 100% shrub mortality and 80% char canopy cover, usually contain no epiphytic lichens and moss. Even >10 years after fire, we observe extremely slow lichen recolonization in dense cheatgrass burned sites. This may be partially due to immediate re-invasive of dense cheatgrass after fire. There are several studies across the West that have documented both the declines in biocrust cover after fire with the increase in cheatgrass. Lichen often grow < 1 mm in 1 year (1" in 25 years) once established. Although lichen communities may take as long as a century or more to reach late-successional community composition, this may be one of the first reports of lichens almost entirely failing to establish for >10 years after disturbance on the Front Range of Colorado. Our findings of long-persisting lichen diversity losses raise new concerns about the sustainability of lichen populations in dense cheatgrass infested, fire-prone areas as fires become larger, more severe, and frequent.

What Does Repeated Rapid Landscape Monitoring Tell Us About Invasive Annual Grass Treatment? Jaycie N. Arndt*[1], Brian A. Mealor[2], Kelsey C. Brock[3], Chloe M. Mattilio[4]; [1]University of Wyoming, Arvada, WY, [2]University of Wyoming Sheridan Research and Extension Center, Laramie, WY, [3]University of Wyoming - Plant Sciences, Laramie, WY, [4]University of Wyoming, Sheridan, WY (147)

Monitoring is the orderly collection, analysis, and interpretation of resource data to evaluate progress toward management objectives. Field based monitoring is key when measuring progress toward invasive annual grass (IAG) adaptive management in rangelands. Although field methods can be time consuming and expensive, they provide beneficial information on ecosystem composition that may be more applicable at smaller scales than current remote sensing capabilities. We systematically conducted repeated rapid monitoring on 60,000 acres of a total of 130,000 acres of IAG-invaded landscapes aerially-treated with indaziflam over the last five years (2018-2022). We used plotless ocular estimation to assess canopy cover of annual grasses by species and pooled perennial grass cover in 2020-2023. We analyzed data from all monitored locations pooled within individual treatment years for the mean and 95% confidence intervals of annual grass and perennial grass cover through time. Ventenata (*Ventenata dubia*) cover decreased from 13.5% (± 1.76%) cover pre-treatment to 2.67% (± 0.73 %), 2.62% (± 1.0%), and 5.10% (± 2.18%) cover one, two, and three years after treatment (YAT) respectively. Cheatgrass (*Bromus tectorum*) cover decreased from 12% (± 1.56%) cover pre-treatment to 4.42% (± 0.96%), 2.61% (± 1.03%), and 2.83% (± 1.31%) cover one, two, and three (YAT) respectively. Perennial grass cover increased from 40.9% (± 2.12%) cover pre-treatment to 53.1% (± 1.95%), 56.8% (± 2.69%), and 54.7% (± 5.15%) cover one, two, and three (YAT) respectively. When summarized across the landscape, we see decreased IAG and increased perennial grasses over time, but traditional summary statistics alone may obscure spatially explicit responses on the landscape. Visual representation of data via maps is

necessary to build a more complete understanding of landscape-scale IAG treatments and their impacts on plant communities. Overall, field based monitoring is helpful for assessing treatment outcomes and providing evidence for informed annual grass management decision-making.

Carbon on the Range: Impacts of Exotic Annual Grass Invasion and Wildfire. Harold Quicke*[1], Toby Maxwell[2], Samuel J. Price[3], Matthew Germino[3]; [1]Environmental Science US LLC, Windsor, CO, [2]Boise State University, U.S. Geological Survey, Boise, ID, [3]U.S. Geological Survey, Boise, ID (148)

Ecological disturbance can affect carbon storage and stability and is a key consideration for managing lands to preserve or increase ecosystem carbon as a "natural climate solution" to the Greenhouse Gas problem. Dryland soils are massive carbon reservoirs that are increasingly impacted by species invasions and altered fire regimes, including the exotic-grass-fire cycle in the extensive sagebrush steppe of North America. Direct measurement of total carbon in 1184 samples from landscapes of this region that differed in invasion and wildfire history revealed that their impacts could deplete 49% (24.8-29.0 Tg) of soil carbon primarily in deep horizons, across the >500,000 ha affected annually. Disturbance effects on soil carbon stocks were not synergistic, suggesting that soil carbon was lowered to a base-level 'floor', beneath which further loss was unlikely. Restoration and maintenance of resilient dryland shrublands/rangelands could ecologically stabilize soil carbon at magnitudes that are relevant to the global carbon cycle.

Update of Long-term Cheatgrass Control Benefits on Boulder County Open Space Properties. Joe Swanson*; Boulder County Parks and Open Space, Longmont, CO (149)

Boulder County Open Space (BCPOS) manages properties in the lowland, foothills and mountains of Colorado that provide critical wildlife and pollinator habitat with highly diverse ecosystems. A major concern of BCPOS ecologists is the loss of critical wildlife habitat, ecosystems, and dynamic diversity of native plant species due to cheatgrass and cheatgrass-fueled wildfires. Invasive winter annual grasses, such as cheatgrass (*Bromus tectorum* L. and *Bromus japonicus*) are considered serious threats to regional biodiversity. This is a summary of long-term as well as newly discovered benefits of long term cheatgrass control with Rejuvra (Indaziflam from Envu) conducted on BCPOS properties. We monitored species diversity and geo-reference native species densities at 12 large-scale, highly diverse sites 5 to 7 years after treatment that are 5 to 40 acres in size in Boulder County. All 12 sites are classified as B1 Natural Heritage Society global significance, high diversity, and rarity ranking. We evaluated the presence or absence of each native species using belt-diversity sampling in Rejuvra verses immediately adjacent non-sprayed areas. We have found that it is critical to monitor species on larger, operational scale Rejuvra treated areas to encompass the impacts to native species on a broad diversity of soils, aspects, slopes, and ecosystem regimes that would be difficult to determine with small plots and quadrats. One concern with Rejuvra has been the long-term impacts it may have on short-lived native plants that's lifecycles depend upon successful seed reproduction for regeneration. We monitored 35 different short-lived native annuals, monocarpic, biennial, and short-lived perennial species at 12 sites in 2023. Short-lived native species took full advantage of the excellent moisture availability in 2023. Several short-lived species have emerged in relatively high numbers the first year after Rejuvra treatments. This is likely in response to the opening of the canopy and lack of competition with

dense cheatgrass control. We have discovered that many short-lived species have long-lived, remnant, soil seed reserves that is waiting for just the right conditions to germinate. We have also found that it is important to monitor Rejuvra-sprayed areas for long-term cheatgrass control and native species response to determine long term-trends that exist. A successful example of this is slimpod venus looking glass (a S1 annual, rare species in Colorado). Slimpod was not present in geo-referenced sites in 2019 - 2022; however, there were 583 slimpod plants that emerged in 2023. This is an example of resiliency of a native annual specie's remnant seed waiting in the soil profile for ideal conditions before germinating. This iconic rare annual species was not present the previous 5 years that this site was monitored and illustrates the importance of long-term monitoring before coming to conclusions about the presence and absence of relict species. We have yet to find the elimination of any short-lived native species over the 7+ years we have been closely monitored the 12 diverse Rejuvra treated sites. There have been no native species found in dense cheatgrass infested checks that were eliminated in Rejuvra sprayed sites 4 to 7+ years after treatment (YAT). In most cases diversity of these species significantly increased compared to adjacent dense cheatgrass infested areas. With recent concern and debate over Rejuvra's impacts to short-lived species, we plan on closely monitoring long-term impacts to short-lived species at multiple locations that are 1 to 8+ YAT in 2024. We have been highly cautious about the long-term impacts indaziflam treatments have on Natural Heritage Society global, state, and local significance rare and special concern species and communities. We were excited to discover 3 rare species that appeared in 2023 for the first time on the 3 of the 12 Rejuvra sprayed sites we have closely monitored. These include slimpod venus looking glass (mentioned above), bird's foot violet, and pale blue-eyed grass. Rare species diversity and densities continue to increase on sites 5 to 7+ years after cheatgrass has been controlled. In contrast, adjacent untreated sites with dense cheatgrass often fail to have these iconic species or they are in extremely reduced numbers. There is good reason native species have rare or concern ratings. This is often in response to their inability to compete with highly invasive and competitive weed species. There were 4 rare species present in Rejuvra sites the first year we started monitoring in 2019 (1 to 3 YAT). Rare species diversity increased to a high of 8 species in 2023 (5 to 7+ YAT). New species appearance was likely due to remnant seed germinating in Rejuvra treated site's soils since these species were missing in previous years. Three other rare specie's community success stories showing resiliency to Rejuvra include Mexican feathergrass, hackberry (a key pollinator species), and the bitterbrush/needleandthread complex. Aerial cheatgrass treatments occurred on March 20, 2019 on approximately 500 acres on Rabbit Mountain Parks and Open Space north of Lyons, Colorado with Rejuvra (7 oz/A) + Plateau (5 oz/A) + MSO via helicopter. Paired treatment and control sites with similar slope, aspect, and supporting plant communities with similar habitat types were evaluated for species cover, diversity, and biomass. We established paired camera traps at each study site beginning on February 1, 2023. Sites with cameras were changed every month to encompass different habitat types that possibly included different small mammal (mice and rabbits), bird, reptile, and amphibian species. Predators (bobcats, coyotes, skunks, and mink) and birds were also recorded by species. Habit types included creek bottom, open grass meadow, rocky shrub hillside, and rocky shrub flat. It was possible to positively identify different wildlife species within proximity of the cameras. We quantified species presence with monthly totals. Canopy cover of each weed, native forb, native shrub, and native grass species was recorded by species at the end of each monthly photo period. We also established paired camera trap sites on other

properties monitored 2 to 7+ years after treatment. These sites were established to determine long-term wildlife preference and response in timeframes after application. Our hypothesis is that with higher diversity and richness of desirable native vegetation species that there will be similar positive diversity and preference by wildlife to areas where dense cheatgrass is removed. We collaborated with CSU to explore the impact of Rejuvra on plant communities and soil bacteria, archaea, and fungi through a five-year series time gradient since treatment. CSU found that treatment had a significant effect on the composition of the soil microbiome. The changes in plant community and soil health may be the drivers of this change, as application of Rejuvra significantly increased native plant presence, and decreased cheatgrass plant and thatch cover by as much as 80%. The Rejuvra application also significantly increased soil nitrate (NO3 -) and decreased soil organic matter. Results of this study indicate that these ecosystem changes due to Rejuvra application are drivers of soil microbial composition, as soil NO3 - , soil organic matter, soil pH, cheatgrass cover, and interactions between them are all also significantly related to community composition. Further, an indicator species analysis suggested that Rejuvra application to a cheatgrass invaded space may shift the soil microbial community from engaging in ammonia oxidation to nitrogen digestion. Our results particularly point towards changes in plant community composition, NO3 and organic matter cycling, and soil pH, as primary drivers of microbial composition change after Rejuvra application. Many studies have shown that cheatgrass invasion increases soil nitrogen, and recent work by the USDA found that NO3 - increased after Rejuvra application and subsequent cheatgrass removal (Green et al., 2019; Morris et al., 2016). Further, the findings of our study that Rejuvra application reduced cheatgrass cover by 80%, and that organic matter decreased after application, point to changes in both the carbon and nitrogen cycling of sites after treatment. These changes are likely what the soil microbiome is responding to, as both PERMANOVA and indicator species analysis suggest.

Boulder County Open Space (BCPOS) manages properties that include high plains, foothill's shrub steppe, and mountain ecosystems in Colorado. These properties provide critical wildlife and pollinator habitat within highly diverse ecosystems. Of major concern is the loss of critical wildlife habitat, diversity of native plants, and specialized ecosystems, due to cheatgrass and cheatgrass-fueled wildfires. Invasive winter annual grasses, such as cheatgrass (*Bromus tectorum* L.) are considered serious threats to regional biodiversity. Cheatgrass competes directly with short-lived native annual, biennial, and short-lived perennial species. Indaziflam (Rejuvra, Envu) which has been labeled for open space, natural areas, and grazing, has been adopted by land managers to help control cheatgrass infestations. Field studies at Colorado State University have demonstrated that indaziflam provides superior long-term BROTE control (3 plus years) with no documented injury to native perennial species. With cheatgrass control, the resulting voids and gaps that are created in the landscape, allow remnant native plants to take full advantage of these sites. BCPOS has monitored species diversity and has geo-referenced native species densities at 12 large-scale (5-40 acre), highly diverse sites, 4 to 6 years after treatment. All 12 sites have a B1 Natural Heritage Society (NHC) global significance, high diversity, and rarity rankings. BCPOS evaluated the presence or absence of each native species using belt-diversity sampling in indaziflam treated sites versus adjoining non-treated sites. This has been critical for monitoring species on sites with a broad diversity of soils, aspects, slopes, and ecosystem regimes that would be difficult to measure with small plots and quadrats. One concern of indaziflam is the long-term impacts it may have on

short-lived native plants which depend upon successful seed reproduction for regeneration. BCPOS monitored 27 different annual, monocarpic, biennial, and short-lived perennial native species at 12 sites. This monitoring also includes long-term impacts indaziflam may have on species that are rare, of special concern and/or communities that the NHC have listed as having global, state, or local significance. BCPOS collected density numbers of rare and short-lived species within 1 to10-acre grid areas, to determine each species population trends and distribution. Large geo-referencing grid blocks were used to complement the belt-diversity sampling method. Using GPS, 7 rare and/or species of special concern at these 12 sites (1 to 6 years after treatment) and short-lived species at 3 separate sites, were geo-referenced. While no decrease in density or diversity of rare or short-lived species has been documented, extreme caution should be used when considering the use of indaziflam where native annual grass, or rare species exist. Additional geo-referencing work has also been done with forked three-awn (*Aristida basiramea*) a rare GS5S2 species of concern, to establish baseline population data. As annual grass species tend to be sensitive to low rates of indaziflam we will continue to monitor long-term impacts cheatgrass and indaziflam may have on forked three-awn and other short-lived, rare grass species. These studies will continue in 2023. Belted grid and geo-referencing monitoring techniques have demonstrated to be valuable for monitoring long-term cheatgrass impacts to native species diversity and density trends over large-scale areas. Our findings reinforce the conclusive evidence from other field managers, that cheatgrass and other invasive annual grasses pose a significant threat to native species diversity. For land managers, this management tool provides a long-term control option to begin the restoration process on large-scale areas infested with cheatgrass.

WSWS PROJECT 2: WEEDS OF HORTICULTURAL CROPS

Tankmixing Bicyclopyrone and Bromoxynil Herbicides for Post-Emergence Weed Management in Direct-Seeded Onion. Joel Felix*; Oregon State University, Ontario, OR (096)

Currently, all post emergence weed control in the Treasure Valley of eastern Oregon and southwestern Idaho begin when onion plants are at least at the two-leaf stage. This presents a challenge when weather conditions prevent application of pendimethalin delayed-PRE resulting in high weed pressure before onion plants are old enough for POST bromoxynil plus oxyfluorfen. Therefore, there is a need for early POST herbicide labels starting when plants are at the one-leaf stage. Bicyclopyrone is a group 27 herbicides that recently received EPA registration to manage weeds in various crops including dry bulb onion, green onion, and garlic. The current label allows applications as PRE or POST directed to onion row middles only. A field study was conducted at the Oregon State University's Malheur Experiment Station, Ontario, OR to evaluate onion response and weed control with tank mixtures of bicyclopyrone plus bromoxynil at various rates starting when plants were at one-leaf stage. Applications at one-leaf stage included standalone bicyclopyrone at 12.8, 25.6, 51, or 102 g ai ha^{-1} or bicyclopyrone 12.8, 25.6, 51 g ai ha^{-1} each tank-mixed with bromoxynil 70 g ai ha^{-1}. Other treatments included bicyclopyrone 25.6, 51, or 102 g ha-1 tank-mixed with bromoxynil 140 g ai ha-1 when onion plants were at the two-leaf stage. A grower standard comprised of delayed-PRE pendimethalin 1,060 g ha^{-1} followed by tank-mixture of bromoxynil 210 g ai ha^{-1} plus oxyfluorfen 140 g ai ha-1 when onion plants were at the two- and

four-leaf stages was included. At 6 days after bicyclopyrone application, onion plant height ranged from 17.3 to 18 cm plant^{-1} across bycyclopyrone treatments compared to 18.2 cm plant^{-1} for the grower standard. Evaluations at 40 days after one-leaf application indicated 5% injury from bycyclopyrone 51 g ai ha-1 and 39% for bicyclopyrone at 102 g ai ha-1. Similarly, injury for tank mixtures comprised of bicyclopyrone 25.6 or 51 g ai ha-1 plus bromoxynil 70 g ai ha-1, was 5% and 29%, respectively, compared to o% for the grower standard. Total weed count at 44 days after the last herbicide application ranged from 0.16 to 0.43 plants m^{-2} for standalone treatment or 0 to 0.03 plants m^{-2} for tankmixes with bromoxynil at one-leaf stage. Marketable yield ranged from 98.5 to 112.9 T ha^{-1} for standalone treatments at 94.5 to 106.4 T ha^{-1} for tankmixes of bicyclopyrone plus bromoxynil compared to 110.6 T ha^{-1} for the grower standard. These results suggested potential for safe use of bicyclopyrone plus bromoxynil at reduced rates to manage weeds in onion starting when plants are at one-leaf stage.

Reducing Hand Hoeing in Chile Pepper by Controlling Weeds in a Rotational Sorghum Crop. Ram Singh Insa*, Brian Schutte, Erik A. Lehnhoff; New Mexico State University, Las Cruces, NM (097)

Broadleaf weeds in chile pepper may be reduced with rotational grass crops, provided such crops encourage weed emergence and feature effective weed control methods that permit rotation to chile pepper the following growing season. To test this hypothesis, we studied the effects of postemergence, nonresidual herbicides applied in sorghum grown with 40-inch row spacing (wide-row sorghum) on weeds and weed management in chile pepper grown on the same land as sorghum in the subsequent year. Our four experimental treatments were: 1) no weed control, 2) a premix combination of 2,4-D (0.35 kg ha-1), bromoxynil (0.35 kg ha-1), fluroxypyr (0.14 kg ha-1) applied at the 4-leaf stage of sorghum, 3) the aforementioned premix combination followed by bromoxynil (0.28 kg ha-1) applied at the 6-leaf stage of sorghum, and 4) total weed control using hand hoeing. Our response variables included percentage cover for broadleaf weeds in sorghum at harvest, and broadleaf weed density and hand hoeing time cumulative across the growing season for chile pepper. Results indicated broadleaf weeds covered less than 5% of ground in sorghum treated with herbicides. Herbicides in sorghum caused 55-60% reductions in broadleaf weeds in chile pepper, and 20% reductions in hand hoeing time, compared to the non-treated control. These percentage reductions caused by herbicides in sorghum were similar to percentage reductions caused by total weed control in sorghum. Results of this study suggest wide-row sorghum treated with postemergence, nonresidual herbicides is an effective method for reducing broadleaf weeds in chile pepper grown the following year.

Adapting Solarization and Biosolarization Technology to Low Desert Agriculture. James J. Stapleton*; University of California, Parlier, CA (098)

Abstract not Available

Crop Safety and Weed Control in Organic Highbush Blueberries Using Electrical Weeding. Luisa C. Baccin*, Marcelo L. Moretti; Oregon State University, Corvallis, OR (099)

Electrical Weed Control (EWC) presents a pioneering approach to weed management, particularly for organic blueberry production, which traditionally relies on mulching. This study aimed to evaluate the performance of EWC in conjunction with different mulching strategies on weed control and crop tolerance in highbush blueberries. The experiment was designed as a two-factor factorial design, incorporating three mulching treatments: bare ground, sawdust, synthetic mulch, and three weed control methods: mowing, EWC at 15 and 75 MJ ha^{-1}; a nontreated was included as a reference. EWC was applied using the EH30 Thor, a tractor-powered electrical weeder, administered six times between March and October 2023. First-year results indicate that EWC at 15 and 75 MJ ha^{-1} significantly reduced weed species diversity (2 species) compared to mowing (10 species). The primary weed species surviving EWC was field bindweed. No adverse effect on soil health as indicated by biological indicators. Moreover, the weed control method did not affect leaf chlorophyll content (mg/m^2) as measured by a direct readout of chlorophyll, or major (N, P, K, Ca, Mg mg/kg) and minor (Mn, Cu, Zn, B, Mo, Fe mg/kg) nutrient content. All weed management strategies resulted in higher canopy volumes (3-fold) and shoot lengths (1.5-fold) than the nontreated control, while the number of fruiting buds remained unaffected. These results underscore the potential of EWC as an environmentally friendly alternative for weed management in organic blueberry farming. Future research will focus on the long-term implications of EWC on soil health, crop tolerance, and profitability of organic blueberries.

Onion Response to Bicyclopyrone Applied Pre-Emergence to Manage Weeds in Direct Seeded Onion. Joel Felix*; Oregon State University, Ontario, OR (100)

Bicyclopyrone, which is marketed by Syngenta® under the trade name Optogen™, recently received registration for weed management in various crops including dry bulb onion, green onion, and garlic. It is a Group 27 herbicide with systemic pre-emergence and post emergence activity for selective contact and residual control of broadleaf weeds. The current label allows PRE broadcast applications at rates ranging from 38 to 51 g ai ha^{-1} or POST-directed applications in row middles at 51 g ai ha^{-1}. Field studies were established in 2023 at the Oregon State University's Malheur Experiment Station, Ontario, OR to evaluate the response of onion cultivar 'Granero' and weed control with bicyclopyrone applied PRE or delayed-PRE at 12.8, 25.6, 51, or 102 g ai ha^{-1} compared to the industry standard comprised of delayed-PRE application of pendimethalin at 1,060 g ai ha^{-1} when 75% of the seeds were determined to have germinated but not emerged. All PRE and delayed-PRE treatments were followed by bromoxynil 210 g ai/ha + oxyfluorfen 140 g ai ha^{-1} POST when onion plants were at the 2- and 4-leaf stages. At 24 days after PRE or Delayed-PRE bicyclopyrone applications, onion plant population density varied across treatments ranging from 131,015 to 285,407 plants ha^{-1} compared to 297,366 plants ha^{-1} for the untreated and 267,195 plants ha^{-1} for the industry standard. The average onion plant height at 24 days after PRE or delayed-PRE, ranged from 16.3 to 18.3 cm $plant^{-1}$ across all treatments. The Total number of weeds at 82 days after herbicide application decreased as the herbicide rate increased ranging from 3.16 plants m^{-2} with bicyclopyrone at 12.8 g ai ha^{-1} to 0.09 plants m^{-2} with bicyclopyrone at 102 g ai ha^{-1} for PRE treatments. The number of weeds was 0.35 to 3.11 g m^{-2} across delayed-PRE treatments. Weed fresh biomass ranged from 0.1 to 0.49 g m^{-2} across PRE treatments or 0.04 to 0.29 g m^{-2} for delayed-PRE treatments, compared to 0 g m^{-2} for the industry standard and 22.51 g m^{-2} for the untreated control. Total marketable onion yield varied across herbicide treatments.

Yield for PRE applied bicyclopyrone at 12.8, 25.6, 51, or 102 g ai ha^{-1} was 94.9, 103.8, 97.1, or 59.4 T ha^{-1}, respectively. The respective yield when bicyclopyrone was applied delayed-PRE was 110.9, 112.1, 108.6, and 88.2 T ha^{-1}. Onion bulb single centers were not affected by herbicide rate or application timing. The results may have been affected by spring weather conditions at the site, which was characterized by relatively cold soil and air temperature at the time of herbicide application. The study will be repeated in the 2024 growing season.

Progress Toward In-season Chemigation Treatments for Branched Broomrape Management. Matthew Fatino*, Brad Hanson; University of California, Davis, Davis, CA (101)

Numerous detections of the parasitic weed branched broomrape (*Phelipanche ramosa*) in California tomato fields have led to increased interest in management strategies to control this quarantine pest. Broomrapes (*Phelipanche spp.* and *Orobanche spp.)* are obligate parasites that pose a significant risk to the processing tomato industry for several reasons: California's Mediterranean climate is similar to that of branched broomrape's native range, California agronomic practices make the spread of broomrape within and among fields likely, and broomrape's phenological development makes it difficult to monitor and inaccessible to conventional weed control practices.A trial was conducted in 2023 evaluating several herbicide programs for in-season branched broomrape control in processing tomatoes. Treatments included chemigated rimsulfuron alone ,chemigated rimsulfuron plus preplant incorporated sulfosulfuron, foliar maleic hydrazide, and various application timings of all treatments. Broomrape emergence was monitored weekly throughout the season and clusters were marked and recorded.All treatments significantly reduced broomrape emergence versus the control. Although there were no significant differences in broomrape emergence among treatments, the best performing treatment numerically was preplant incorporated sulfosulfuron and chemigated rimsulfuron applied according to a growing degree day calendar. The numerically lowest broomrape control treatment was preplant incorporated sulfosulfuron alone. There were several treatments that mimicked the recently approved 24c Special Local Needs label for chemigated rimsulfuron and all had significantly lower broomrape emergence than the control treatment and future research will further refine application timing to optimize this treatment.

Florpyrauxifen for Orchard Floor Weed Management in Western Tree Nuts. Jesse M. Richardson*[1], Stephen F. Colbert[2], Kelly A. Backscheider[3]; [1]Corteva Agriscience, Mesa, AZ, [2]Corteva Agriscience, Escalon, CA, [3]Corteva, Franklin, IN (130)

Field studies were conducted in California and Arizona to test the efficacy and crop safety of florpyrauxifen on key weed species. No evidence of crop injury, chlorosis or necrosis was detected at 2, 4, and 6 weeks after herbicide applications at all locations. Florpyrauxifen controlled little mallow (*Malva parviflora*), whitestem filaree (*Erodium moschatum*), and hairy fleabane (*Erigeron bonariensis*). Palmer amaranth (*Amaranthus parmeri*) was controlled with a tank mixture of florpyrauxifen with either glyphosate or 2.4-D choline.

Control of Italian Ryegrass, Yellow Nutsedge, and Hazelnut Suckers with EXP KD1. Joshua W. Miranda*[1], Tye C. Shauck[2], Marcelo L. Moretti[1]; [1]Oregon State University, Corvallis, OR, [2]BASF Corporation, Roslyn, WA (131)

Effective weed management in hazelnut orchards is vital for ensuring sustainable and profitable nut production. The escalating challenges posed by herbicide-resistant Italian ryegrass, coupled with the need for effective yellow nutsedge control and hazelnut sucker management, underscore the importance of identifying new effective solutions. EXP KD1 is an herbicide under development for tree nut crops. The objective of this study was to evaluate the effect of two formulations of EXP KD1 on Italian ryegrass, yellow nutsedge, and hazelnut suckers. EXP KD1 and 2 effectively controlled suckers at the proposed labeled rate of 2.74 fl oz/A, and performed similarly to glufosinate (56 fl oz/A) in field studies conducted between 2022 and 2023. However, EXP KD1 applied at 2.74 fl oz/A outperformed the 1.37 fl oz/A rate. Control of Italian ryegrass was dependent on the experimental site. EXP KD1 at 4.11 fl oz/A alone or mixed with glyphosate, as well as EXP KD2 mixed with glufosinate, provided the greatest Italian ryegrass control (57 to 63%). The combination of EXP KD2 with glyphosate proved to be the most effective herbicide treatment to control yellow nutsedge, showing 84% yellow nutsedge control and 81% biomass reduction. Despite these positive outcomes, regrowth of yellow nutsedge was observed across all treatments, highlighting the necessity for additional control measures. These results support that EXP KD1 effectively controls hazelnut suckers compare to current benchmarks, and the mixture of EXP KD1 can improve control of Italian ryegrass and yellow nutsedge in hazelnut orchards. Therefore, EXP KD1 offers a potential solution to simultaneously address weed and sucker management, two labor-intensive aspects of hazelnut production.

Managing Italian Ryegrass in Hazelnut Orchards with Electricity. Marcelo L. Moretti*; Oregon State University, Corvallis, OR (132)

Herbicide-resistant Italian ryegrass (*Lolium multiflorum* Lam.) presents a significant challenge in hazelnut orchards across Oregon, with confirmed resistance to multiple herbicide modes of action groups (1, 2, 9, 10, 15, and 22). In response, four field studies were conducted in 2023 to evaluate nonchemical and chemical methods for controlling Italian ryegrass during spring. Tested treatments included mowing at 2 km h^{-1}, electric weeding control (EWC) at 15 MJ ha^{-1} (2 km h^{-1}), and glufosinate application at 1.68 kg ai ha-1, administered once or twice. Furthermore, combinations of EWC with mowing or glufosinate were examined, resulting in eleven treatments. EWC was performed using alternating current and 30 kW (EH-30 Thor, ZassoTM), treating swaths 1.2 m wide. Assessments conducted 56 days after initial treatment (DAIT) revealed that single mowing showed no significant difference compared to untreated plots. However, when mowing was performed twice, it led to a 30% reduction in inflorescence density and an 84% reduction in weight. EWC, applied once or twice, resulted in significant decreases in Italian ryegrass inflorescence density (51-58%), weight (55-73%), and shoot weight (45-75%) compared to untreated plots, with no significant differences observed between single or double applications. Similarly, glufosinate applied once or twice substantially reduced Italian ryegrass inflorescence density (68 to 86%) and weight (73 to 93%). Combinations of EWC with mowing or glufosinate demonstrated high efficacy, achieving control rates of 89 to 96% and exhibiting comparable efficacy to two applications of glufosinate (96%). These findings suggest that EWC, when applied during the spring period, can effectively control Italian ryegrass, offering comparable efficacy to glufosinate and superior efficacy to mowing.

Barley Cover Crops Outperform Brown Mustard for Early-season Weed Control of New Mexico Chile Pepper. Caroline R. Toth*, Brian Schutte; New Mexico State University, Las Cruces, NM (133)

Barley (*Hordeum vulgare* L.) and brown mustard (*Brassica juncea* L.) are winter cover crops with allelopathic properties. Incorporating barley and brown mustard residues into the soil of a spring-seeded cash crop may suppress early-season weeds; however, the comparative levels of weed suppression offered by barley and brown mustard cover crops incorporated into soil have not been determined. This study analyzed the relative capacities of barley and brown mustard cover crops to suppress early season weeds of spring-seeded chile pepper (*Capsicum annuum* L.). Reductions in weed density or hand hoeing time as a result of barley and/or brown mustard cover crop treatment were evaluated as measurements of weed suppression in two chile pepper fields in New Mexico over two growing seasons. A subsequent controlled environment study confirmed the effects of barley-amended soil on the germination of Palmer amaranth (*Amaranthus palmeri* S. Wats.), a common weed of chile pepper. Field study results indicated barley reduced early-season weed densities of chile pepper in two of four site-years and reduced hoe time in three site-years. Mustard cover crops only reduced density in one site-year and did not decrease hoe time. The controlled environment study indicated that soil amended with barley slowed the germination process of Palmer amaranth. The results of this study indicate that a barley cover crop is superior to brown mustard for early-season weed control of chile pepper in southern and central New Mexico.

Overcoming Weed Competition During Pollinator Habitat Establishment. Ryan J. Hill*[1], David R. King[2], Marcelo L. Moretti[2]; [1]UC ANR, Red Bluff, CA, [2]Oregon State University, Corvallis, OR (134)

Providing quality habitat to pollinator insects can contribute meaningfully to their health, efficiency, and resiliency to pesticide exposure in agricultural fields. Weed competition and soil preparation are important considerations when seeding agricultural fields with pollinator-friendly plant species. If these topics are not considered the likelihood of failure is high. This work was initiated to develop better weed control recommendations for pollinator plantings. Two trials were established in the inter-rows of Willamette valley hazelnut farms in October 2020 and a third trial was planted in a field at Oregon State University's Lewis-Brown Horticultural Research Farm in October 2021. Soil was either plowed and disked, power harrowed, or untilled. Seven pollinator species were drill-seeded at recommended rates and treated with 8 herbicides pre-emergence and 4 herbicides 45 days after emergence. Herbicide efficacy and crop tolerance was assessed periodically throughout the year and crop biomass was collected in summer. Results varied greatly depending on soil preparation and weed control methods. Only *Vicia villosa* grew well in the untilled soil and was not strongly affected by weed competition in any of the trials. Both a preemergent application of simazine and a postemergent application of bentazon were well tolerated by *Vicia villosa* in these plantings. All other species greatly benefited from tillage prior to planting and a preemergent application of glyphosate. For these species the preemergent glyphosate treatment improved pollinator crop coverage by at least 6-fold. Preemergent herbicides also improved crop coverage, but successful combinations varied by species. Napropamide was successful at improving coverage of *Clarkia amoena*, *Gilia capitata*, and *Lobularia maritima*.

Pendimethalin and flumioxazin were tolerated by *Eschscholzia californica*. *Phacelia tanacetifolia* competed with weeds exceptionally well but also tolerated napropamide. *Onobrychis viciifolia* seemed to tolerate napropamide but poor weed control made this combination only moderately effective. Interestingly, *O. viciifolia* plants were observed in plots treated with indaziflam 18 months after treatment, though coverage had remained very low for the first 12 months after planting. More research will be needed to determine how tolerant this species is of indaziflam. Untreated control plots were often devoid or nearly devoid of the planted species, strongly supporting the assertion that weed control is an essential consideration when attempting to establish pollinator habitat.

Twists and Turns: Effects of Simulated Excess Rainfall on Potato Crop Injury. Pamela J.s. Hutchinson*[1], Brent Beutler[2]; [1]University of Idaho, Aberdeen R & E Center, Aberdeen, ID, [2]University of Idaho, Aberdeen, ID (135)

Precipitation in the form of rain across the potato production region of southern Idaho is usually highest in the months of April and May and can range from 1 to 3 inches. In 2018 and 2019, however, the amount of rainfall during those two months reached 6 inches in some areas. This excess rainfall during the typical time of potato planting occurred in many places after preemergence potato herbicides had already been applied via chemigation or with ground rig and sprinkler incorporation. Southern Idaho soils are coarse-textured. Injury was observed in grower fields consisting of unusual belowground sprout twisting, poor emergence, and/or poor aboveground plant growth. A study simulating excess rainfall after preemergence herbicide application was conducted at the University of Idaho Aberdeen Research and Extension Center in 2021, 2022, and 2023 in order to develop a key of injury symptoms to aid in diagnoses. Pendimethalin, dimethenamid-p, metribuzin, or rimsulfuron, representing relative herbicide solubility from low to high was applied preemergence followed by sprinkler irrigation of 3 or 6 in over a period of 2 wks. Amount of natural rainfall during those 2 wks was accounted for so that the total was kept at 3 or 6 in. Preemergence herbicides with no excess rainfall simulated by sprinkler irrigation were included in the trial for comparison. Injury symptoms similar to those in 2018 and 2019 grower fields were observed. Although pendimethalin is one of the potato herbicides with the lowest solubility, effect on shoots was prominent when it as applied followed by 6 in rainfall. Crinkled and malformed leaves were seen in the dimethenamid-p treatments with 3 or 6 in rainfall, leaf veinal chlorosis usually occurred in the 3 but not 6 in metribuzin treatments, and stunting was observed when rimsulfuron was applied followed by 3 or 6 in simulated rainfall. Soil samples from 0 to 4, 4 to 8, and 8 to 12 in depth were collected from each herbicide x excess rainfall amount treatments and are being analyzed for determining herbicide movement to correlate with injury symptoms.

Can Application Timing Reduce Potential Flumioxazin Injury to Potato? Harlene M. Hatterman-Valenti*, Collin P. Auwarter; North Dakota State University, Fargo, ND (136)

Growers have few broadleaf weed control options in potato. The group 3 and 15 herbicides labelled in potato primarily control annual grasses and some annual broadleaves. Metribuzin alone or plus rimsulfuron is the primary broadleaf herbicide. However, both only provide fair common lambsquarters (*Chenopodium alba*) control and poor control of many nightshade (*Solanum spp.*)

species. Flumioxazin provides good/excellent control of these two species but has also caused injury. The label restricts its use in potato to only 25 states that includes North Dakota to alleviate most of the potential potato injury. The label further restricts and limits the herbicide application timing and states: Many weather-related factors, including high wind, splashing or heavy rains or cool conditions at or near potato emergence, may result in potato injury in fields treated with Chateau EZ Herbicide. Furthermore, the label states: In areas with historically higher amounts of rainfall during the time of preemergence herbicide applications, including the Red River Valley, Minnesota and North Dakota, the requirement for 2 inches of settled soil is critical to avoid crop injury. The objective was to determine the effect of flumioxazin application rate and timing on weed control and 'Russet Burbank' potato safety under irrigation and delayed planting. Treatments included the labeled use rate and half that rate at three application timings: two to three days after planting (DAP) and either hilling before the herbicide application or no hilling, regular hilling at nine to 11 DAP, and then various application timings of flumioxazin and the combination product of metribuzin + metolachlor along with a standard of metribuzin + metolachlor after regular hilling. Results varied with years and indicated that in year one, if no major rainfall occurred shortly after applications, almost all treatments resulted in similar total and marketable yields except the application of flumioxazin ½X 2DAP no hill + metribuzin/metolachlor ½X after regular hilling which resulted in the lowest total and marketable yields as was attributed to lower season-long weed control. However, in years two and three, when more than 2.5 inches of rain occurred within 10 days of either application, the greatest total and marketable yields resulted with the application of flumioxazin 1X 2DAP no hill + metribuzin/metolachlor ½X after regular hilling (tied with four other treatments in year 2) and indicated that the earlier application of flumioxazin and no hilling was a better application timing but only when a hilling occurred at the regular timing. In year 3, the standard flumioxazin application (1X after regular hilling) resulted in a lower marketable yield due to a lower percentage of marketable tubers. In years two and three, flumioxazin applied early (½X and 1X) without any hilling resulted in the lowest total and marketable yields. Yield and grade differences were attributed to the number of tubers produced and tuber size. Overall, the application of flumioxazin 1X 2DAP no hill + metribuzin/metolachlor ½X after regular hilling resulted in the highest marketable when data was combined over years to provide a recommendation to growers.

Yellow Nutsedge Control in Pacific Northwest Potato Production. Rui Liu*[1], Tim Waters[2], Joel Felix[3]; [1]Washington State University, Prosser, WA, [2]Washington State University, Pasco, WA, [3]Oregon State University, Ontario, OR (137)

Abstract not Available

WSWS PROJECT 3: WEEDS OF AGRONOMIC CROPS

Alternatives to Paraquat for Weed Burndown in Alfalfa. Albert T. Adjesiwor*[1], McKenna Carnahan[2], Earl Creech[2], Chandra L. Montgomery[3], James Gomm[1]; [1]University of Idaho, Kimberly, ID, [2]Utah State University, Logan, UT, [3]University of Idaho, Moscow, ID (084)

Weed burndown programs in alfalfa (*Medicago sativa*) have historically relied heavily on paraquat. However, paraquat is a restricted use pesticide and one of the most acutely toxic herbicides used in alfalfa production. To limit the risk associated with paraquat use, the United States Environmental Protection Agency has introduced new safety measures for paraquat use. Although these measures are aimed at ensuring the safe use of paraquat, this may deter growers from relying on the herbicide. It is therefore important to identify effective alternative herbicides to paraquat for weed burndown in alfalfa. Field studies were conducted in Idaho and Utah in 2023 to assess alfalfa recovery and forage yield when treated with carfentrazone, saflufenacil, pyraflufen, tiafenacil, diuron + hexazinone, glyphosate, and paraquat. Although carfentrazone, saflufenacil, and tiafenacil caused greater alfalfa injury and height reduction within the first 3 weeks after herbicide application, the alfalfa recovered within 6 weeks after herbicide application. At the Idaho location, alfalfa forage yield ranged from 2,096 to 2,478 kg ha^{-1} and was statistically similar among all treatments. At the Utah location, forage yield ranged from 2,253 to 3,901 kg $ha^{-1,}$ and only saflufenacil at 50 g ai ha^{-1} and diuron + hexazinone at 1,900 and 3,800 g ai ha^{-1} reduced forage yield compared to the nontreated check. Only diuron + hexazinone at 3,800 g ai ha^{-1} reduced alfalfa forage yield compared to the paraquat treatment. These results showed that carfentrazone, pyraflufen, saflufenacil, and tiafenacil are promising alternatives to paraquat for weed burndown in alfalfa.

EPSPS Copy Number Variation is Correlated with Glyphosate Resistance in Some Italian Ryegrass Populations. Victor Ribeiro*[1], Joseph Gallagher[2], Pete Berry[1], Judit Barroso[3], Carol Mallory-Smith[1]; [1]Oregon State University, Corvallis, OR, [2]United States Department of Agriculture, Corvallis, OR, [3]Oregon State University, Adams, OR (085)

Italian ryegrass (*Lolium multiflorum* Lam.) is a major problem in Oregon agricultural systems. In 2022, a grower reported glyphosate failed to control Italian ryegrass in a fallow field. The objectives of this study were to (1) determine the level of resistance to glyphosate and (2) the mechanism of resistance in this Italian ryegrass population from Oregon. Greenhouse dose-response studies were conducted at Oregon State University, Corvallis, OR, using a randomized complete block design with six replications. Glyphosate rates ranging from 0 to 8X were tested (X = 841 g ai ha^{-1}). Italian ryegrass biomass was collected 21 days after treatment, dried, and weighed. A four-parameter log-logistic model was fitted to the relative biomass (% of control) data to estimate the rate required for a 50% growth reduction and the resistance ratio. *EPSPS* gene sequence analysis and *EPSPS* gene copy number assays were performed. The resistant population was 9.2-fold less sensitive to glyphosate compared with the susceptible population. No mutations were detected in the *EPSPS* gene sites 102 and 106 known to confer glyphosate resistance. An increase in *EPSPS* gene copy number was observed in the resistant population relative to the susceptible population, with a mean of 26 gene copies and a maximum of 122 gene copies. *EPSPS* gene amplification appears to be the mechanism of resistance to glyphosate in Italian ryegrass. To the best of our knowledge, this is the first report of *EPSPS* gene amplification in a glyphosate-resistant Italian ryegrass population in Oregon.

A Quizalofop-p-ethyl and Glufosinate-ammonium Premix - the Rest of the Story. Richard K. Zollinger*[1], Joseph A. Bruce[2], Peter J. Porpiglia[3]; [1]Amvac Chemical Company, Spokane Valley,

WA, [2]AMVAC Chemical Corporation, Glen Carbon, IL, [3]AMVAC Chemical Corporation, Newport Beach, CA (086)

Developed by AMVAC Chemical Company, a soluble liquid formulation was created through ProLease™ Technology containing 27.6 g/L of quizalofop-P ethyl plus 280.4 g/L of glufosinate-ammonium. Postemergence applications for nonselective control of emerged grass and broadleaf weeds can be made up to early bloom glufosinate-tolerant canola (*Brassica napus*), up to 14 days before flower glufosinate-tolerant cotton (*Gossypium herbaceum*), up to bloom soybean (*Glycine max*), and V2 to V6 glufosinate- and quizalofop-P-ethyl-tolerant corn (*Zea mays*). Applications can also be banded and/or directed postemergence spray or spot spray treatment in pome fruit (crop group 11-10) and stone fruit (crop group 12-12), except NY. The premix use rates are from 496 to 968 g/ha on 8 cm tall broadleaf weeds and 13 to 76 cm tall grass weeds. The premix controlled weeds equal to or greater than a tank-mix of commercial formulations of quizalofop-P ethyl and glufosinate-ammonium applied at equivalent active ingredient rates between 7 to 14 days after application. The premix did not influence broadleaf weed control as compared to glufosinate applied alone but grass control increased compared to quizalofop-p ethyl applied alone. Peak herbicide activity of the premix occurred 7 to 14 days after application. The premix was optimized when applied after soil-residual herbicides or tank-mixed with a Group 15 herbicide or applied in sequential applications. Optimum weed control occurred when applied with a spray volume containing medium to course textured spray quality with petroleum oil concentrate plus ammonium sulfate adjuvants. Reduced control of grass weeds occurred when applied with 2,4-D or dicamba but antagonism was removed when the premix was applied 1 day before or 7 days after the broadleaf herbicide. The premix may be mixed with other registered pesticides but antagonism of grass control may occur with some products, particularly herbicides in Group 2, 4, 6, and 14. Reduced weed control occurred when applied in very coarse, extremely coarse, and ultra coarse spray quality. The premix does not provide residual weed control. Crop response from the premix was usually negligible but was often influenced by adverse weather conditions (e.g., temperature, humidity, etc.) which is consistent with normal response to glufosinate-ammonium applied alone. The premix is near unique as containing a non-cereal graminicide with a systemic postemergence broadleaf herbicide and the only premix containing glufosinate-ammonium with a systemic grass herbicide.

Post-emergence Pendimethalin in Herbicide Mixture Applications Effect on Weed Control and Rice Response in Water-Seeded Rice. Aaron Becerra-Alvarez*, Kassim Al-Khatib; University of California Davis, Davis, CA (087)

Herbicides are an important tool for weed management in water-seeded rice. The lack of available herbicides and reduced effectiveness have encouraged research on new herbicides for California water-seeded rice. Because pendimethalin controlled herbicide-resistant grass populations in the greenhouse, it was further researched for use in water-seeded rice. This study evaluated pendimethalin as a post-emergence application for weed control and rice response in a water-seeded system. Pendimethalin was applied alone and in herbicide mixtures at 1.1, 2.3 and 4.4 kg ai ha^{-1} with three broad-spectrum or foliar graminicide herbicides currently available at the 4- to 5-leaf stage rice. At 14 days after treatment, Echinochloa control levels were 68% to 80% when pendimethalin was applied in herbicide mixtures and greater than pendimethalin applied alone.

Echinochloa control was 90% to 100% by 56 days after treatment. The herbicide mixtures with bispyribac-sodium and propanil had broad spectrum control of grass, sedge and broadleaf species compared to the mixture with cyhalofop-butyl, a graminicide herbicide. Additional follow-up treatments were applied for broad-spectrum weed control. All treatments resulted in less than 8% of visual injury. Rice tiller counts and grain yield were not affected by pendimethalin and resulted similar to the standard treatment of clomazone applied at the day of seeding. The results demonstrate pendimethalin can be a potential new herbicide for water-seeded rice when used in conjunction with other herbicides and does not cause injury of concern on rice when applied at 4- to 5-leaf stage. Pendimethalin would assist with herbicide resistance management in California rice.

Storen: A New Corn Herbicide in 2024 That Provides Clean Rows and Clear Results. Nathan H. Haugrud[1], Scott E. Cully[2], Thomas H. Beckett[3], Benjamin C. Westrich*[4], Jafe D. Weems[5], Mark J. Kitt[3]; [1]Syngenta Crop Protection, Fargo, ND, [2]Syngenta Crop Protection, Marion, IL, [3]Syngenta Crop Protection, Greensboro, NC, [4]Syngenta Crop Protection, Loveland, CO, [5]Syngenta Crop Protection, Kennewick, WA (088)

Storen™ is a herbicide from Syngenta Crop Protection delivering broad-spectrum control of annual grasses and key broadleaf weeds in field corn, seed corn, yellow popcorn, and sweet corn. Storen is a ZC (capsule-suspension) formulation that combines four active ingredients, mesotrione, bicyclopyrone, *S*-metolachlor, and pyroxasulfone as well as the safener benoxacor in a convenient premixture. The robust rates of these four active ingredients are designed to work together to provide maximum broad-spectrum residual weed control. The herbicide is optimized for preemergence and postemergence crop safety when used according to the label. Storen is labeled for use in fine and medium textured soils with a wide application window from pre-plant to before corn reaches V8 leaf stage on field corn and seed corn. Storen provides control of 74 weed species including annual grasses and many small-seeded broadleaves such as waterhemp (*Amaranthus tuberculatus*) and Palmer amaranth (*Amaranthus palmeri*) as well as numerous key large-seeded broadleaf weeds such as common and giant ragweed (*Ambrosia artemisiifolia*, *A. trifida*), morninglories (*Ipomoea* sp.), velvetleaf (*Abutilon theophrasti*), and common cocklebur (*Xanthium strumarium*). In field testing, Storen has consistently provided up to three weeks longer residual control of weeds compared to other leading corn herbicides which protects corn from weed competition and results in a 4 to 5 bu/A grain yield advantage.

Florpyrauxifen-benzyl Provides Selective Broadleaf Weed Control in Sugarbeet. Adam Aberle*[1], Thomas J. Peters[2], Joseph Mettler[2], Ryan M. Humann[3]; [1]North Dakota State University Department of Plant Science Extension Sugarbeet, Fargo, ND, [2]North Dakota State University, Fargo, ND, [3]Corteva Agriscience, Fargo, ND (089)

Glyphosate-resistant (GR) waterhemp [(Amaranthus tuberculatus (Moq.) J.D. Sauer)], GR common ragweed (Ambrosia artemisiifolia L.) and common lambsquarters (Chenopodium album L.), are weed control challenges in sugarbeet in North Dakota and Minnesota. Sugarbeet growers control GR waterhemp with soil residual chloroacetamide herbicides (group 15) for waterhemp and control GR common ragweed with clopyralid (group 4). However, growers need additional herbicides to improve broadleaf weed control and to manage the specter of resistance.

Florpyrauxifen-benzyl (Rinskor™) is an auxin mimic herbicide (group 4) which controls susceptible plants by disrupting plant growth processes. Florpyrauxifen-benzyl is labeled as Loyant™ for postemergence grass, sedge, and broadleaf weed control in rice at 30 g ha^{-1}. Sugarbeet tolerance experiments were conducted at three locations to examine two-times florpyrauxifen-benzyl applications on 2- and 6-leaf sugarbeet at 0.25 to 2.0 g ai ha^{-1} followed by (fb) 0.5 g ai ha^{-1} in comparison with the standard sugarbeet herbicide protocol in 2023. Efficacy experiments were conducted at five locations to examine two-times florpyrauxifen-benzyl applications postemergence on 2- and 6-leaf sugarbeet at 0.5, 0.75, and 1.0 g ai ha^{-1} fb 0.5 g ai ha^{-1} with and without standard sugarbeet herbicides. Florpyrauxifen-benzyl at 0.5 fb 0.5 g ai ha^{-1} alone provided poor (40 – 65%) control of waterhemp, fair (65 – 80%) control of common ragweed and excellent (>90%) control of common lambsquarters. Sugarbeet tended to tolerate florpyrauxifen-benzyl at 0.5 fb 0.5 g ai ha^{-1}, however, rates 0.75 to 2.0 g ai ha^{-1} significantly reduced the yield and extractable sucrose.

Optimization of Metamitron Rate Applied PRE in Sugar Beet for Management of Palmer Amaranth. Abraham Akuoko*[1], Phil Westra[2], Chris Proctor[1], Cody F. Creech[3], Nevin Lawrence[3]; [1]University of Nebraska, Lincoln, NE, [2]Colorado State University, Fort Collins, CO, [3]University of Nebraska, Scottsbluff, NE (102)

Multiple dose-response analysis studies were established in NE between 2020 and 2023, with additional trials established in CO in 2023, to determine the optimal rate of metamitron PRE for Palmer amaranth control in sugar beet with and without ethofumesate as a mix partner. Weed control assessment occurred 6 to 8 w after application depending on location. Several locations had low Palmer amaranth density or high kochia densities which contributed to statistical error. Studies in Scottsbluff, NE in 2020; Mitchell, NE; Eaton and Eckley, CO, all in 2023 allowed for proper analysis. Metamitron rates ranged from 0-6.5 kg ai ha^{-1}, while ethofumesate was either included at a fixed rate or not present at all. Locations in NE had low and locations in CO had high populations of Palmer amaranth. At all locations, maximum weed control was obtained from rates near 2 kg ai ha^{-1}, regardless of ethofumesate as a mix partner. Generally, weed control was greater at rates near 1 kg ai ha^{-1} when ethofumesate was included as a mix partner. Weed density followed trends observed with weed control estimates, with greater control obtained at rates between 1-2 kg ai ha^{-1} when ethofumesate was a mix partner, and little differences in control at rates greater than 2 kg ai ha^{-1}, regardless of the inclusion of ethofumesate as a mix partner. Study results were used to support a Section 18 label for metamitron for CO and NE in 2024 at a rate of 3.27 kg ha^{-1}.

Herbicide Strategies to Manage Glyphosate-, Glufosinate-, and Dicamba-Resistant Kochia Populations in Triple-Stacked Sugarbeet Cultivar. Het Samir Desai*[1], Fabian Menalled[1], Lovreet S. Shergill[2]; [1]Montana State University, Bozeman, MT, [2]Montana State University, Huntley, MT (103)

The prevalence of two-way resistant (i.e., glyphosate and dicamba) *Bassia scoparia* A. J. Scott populations poses a significant threat to triple-stacked sugarbeet cropping systems in Northern Great Plains. Our survey conducted in August 2021 identified that 40% of *B. scoparia* populations across Southcentral Montana and Northwest Wyoming evolved two-way resistance. A greenhouse study aimed at evaluating alternate herbicide strategies was conducted in a randomized complete

block design (RCBD) with three replications and three two-way resistant *B. scoparia* populations. Herbicide treatments included POST-emergence tankmix applications of dicamba (0.4 kg ae ha^{-1}) + glyphosate (1.0 kg ae ha^{-1}), dicamba (0.6 kg ae ha^{-1}) + glyphosate (1.3 kg ae ha^{-1}), dicamba (0.4 kg ae ha^{-1}) + glyphosate (1.0 kg ae ha^{-1}) followed by dicamba (0.4 kg ae ha^{-1}) + glyphosate (1.0 kg ae ha^{-1}), and dicamba (0.6 kg ae ha^{-1}) + glyphosate (1.3 kg ae ha^{-1}) followed by dicamba (0.6 kg ae ha^{-1}) + glyphosate (1.3 kg ae ha^{-1}). Sub-optimal efficacy of all POST-emergence tankmix applications was observed as weed control (%) ranged from 10% to 79%. In addition, a separate greenhouse study in RCBD evaluated the efficacy of PRE-emergence applications of dicamba (0.6 kg ae ha^{-1}), ethofumesate (3.4 kg ai ha^{-1}), and dicamba (0.6 kg ae ha^{-1}) + ethofumesate (3.4 kg ai ha^{-1}) on two-way resistant *B. scoparia* populations. All PRE-emergence treatments provided 85-100% control over two-way resistant *B. scoparia* populations. This research provides crucial insights into effective herbicide strategies for managing glyphosate- and dicamba-resistant *B. scoparia* in the Northern Great Plains.

Herbicide-Resistance In Kochia (*Bassia scoparia*) is Increasing in North Dakota. Joseph T. Ikley*[1], Kirk A. Howatt[1], Brian Jenks[2], Quincy D. Law[1]; [1]North Dakota State University, Fargo, ND, [2]North Dakota State University, Minot, ND (104)

Herbicide resistant (HR) kochia (*Bassia scoparia*) has been one of the most problematic weeds in North Dakota (ND) for decades. HR kochia was first identified in the state in 1987 when populations were confirmed resistant to chlorsulfuron and metsulfuron-methyl (Group 2). In the 1990's, populations with resistance to dicamba (Group 4; 1995) and atrazine (Group 5; 1998) were confirmed in wheat and corn fields, respectively. Glyphosate-resistant kochia was first reported in 2012. Resistance to Group 2 herbicides and glyphosate has become widespread across the state. Dicamba-resistant soybean were widely adopted starting in 2017 due to the overall effectiveness of dicamba compared to other soybean herbicides on the market. Subsequently, several populations were collected in the fall of 2022 after surviving multiple applications of glyphosate + 560 g ha^{-1} of dicamba applied in season. These populations were subjected to dose-response trials and resistance was confirmed. Concurrently, several separate populations from western ND were being treated with and surviving discriminating 1x and 2x rates of carfentrazone and saflufenacil in greenhouse trials. The populations with dicamba resistance were further subjected to discriminating 1x and 3x doses of saflufenacil, fluroxypyr, atrazine, glufosinate, and dicamba + diflufenzopyr. Plants were still susceptible to atrazine and glufosinate, suppressed by fluroxypyr, and survived saflufenacil and dicamba + diflufenzopyr treatments. Results confirm that dicamba-resistant kochia is now present in North Dakota. Populations that survived discriminating doses of Group 14 herbicides were selected to be fully characterized, and results will be presented in papers 105 and 106.

Kochia Resistance to Foliar-Applied PPO Herbicides. Quincy D. Law[1], Charles M. Geddes[2], Kirk A. Howatt*[1], Brian Jenks[3], Joseph T. Ikley[1]; [1]North Dakota State University, Fargo, ND, [2]Agriculture and Agri-Food Canada, Lethbridge, AB, Canada, [3]North Dakota State University, Minot, ND (105)

Kochia [*Bassia scoparia* (L.) A.J. Scott] is a persistent and troublesome tumbleweed that can cause substantial interference across arid and semi-arid regions of western North America. Kochia

control has been complicated by development of resistance to various herbicide sites of action. This has led to heavy reliance on PPO-inhibiting herbicides for several crops. In 2021, poor control of emerged kochia was questioned in fields from west-central Saskatchewan to south-central North Dakota following preplant application of PPO-inhibiting herbicides. Seed was collected from six of these locations in 2022 and used along with susceptible seed lots to produce plants 4 to 7 cm tall for bioassays. Whole-plant dose-response analysis was used to investigate the level of resistance to saflufenacil or carfentrazone in three collections, and ANOVA means separation (a=0.05) was used to evaluate cross-resistance among nine PPO-inhibiting herbicides (except N-phenyl-oxadiazolones) with five collections. For dose-response, complete control of susceptible kochia was achieved with 2.5 g ai ha^{-1} saflufenacil, while a few plants survived nearly complete necrosis with 2500 g ha^{-1}. Depending on collections compared, the R/S ratio with saflufenacil ranged from 45 to 330. The Saskatchewan collection demonstrated an R/S ratio of 5 to 8 with carfentrazone, but North Dakota collections had values of 88 to 330. In cross-resistance screening, all nine herbicides provided at least 87% control of susceptible kochia. Diphenyl ether herbicides provided similar control of susceptible and resistant kochia, but other herbicides gave 13 to 66% control of resistant kochia. The confirmed PPO-resistant kochia displayed broad cross-resistance within PPO inhibitors, but diphenyl ether herbicides remained effective.

Kochia Resistance to Soil-Applied PPO Herbicides. Brian Jenks*[1], Kirk A. Howatt[2], Joseph T. Ikley[2]; [1]North Dakota State University, Minot, ND, [2]North Dakota State University, Fargo, ND (106)

Kochia [*Bassia scoparia* (L.) A. J. Scott] populations from western North Dakota recently have been confirmed to be resistant to Group 14 foliar-applied herbicides such as carfentrazone, saflufenacil, tiafenacil, and pyraflufen. In this study, we evaluated seven kochia populations for resistance to soil-applied Group 14 herbicides, sulfentrazone and flumioxazin. Known susceptible kochia populations were used as a control sample. It should be noted that at each collection site, kochia seed was collected from several plants and combined. The study was conducted at greenhouses in Fargo and Minot. Pots (10 x 10 cm) were filled with soil to about 1.25 cm below the top. A thick paper towel was placed in the bottom of the pots to prevent soil from leaking out. Pots were sub-irrigated and allowed to drain until the next morning. Twenty kochia seeds were placed on the soil surface. About 0.3-0.5 cm of soil was added to cover the kochia seeds. Sulfentrazone and flumioxazin were applied over the top using a track sprayer delivering 94 L/ha at 276 kPa. About 4 hours later the herbicides were incorporated with 0.25 cm simulated rain using the track sprayer. The soil surface was misted daily to prevent the surface from crusting. At 21 days after application, kochia plants were counted in each pot and treatments were evaluated for percent kochia control. Kochia plants were cut at the soil surface, weighed, and dried. The study was conducted two times each at Fargo and Minot. The Fargo soil was a sandy loam with pH 7.4 and 3.9% organic matter. The Minot soil was a sandy loam with pH 7.7 and 3.2% organic matter. Kochia density: In both Fargo and Minot soils, sulfentrazone and flumioxazin reduced the susceptible check density to nearly zero. In contrast, in the Fargo soil, both herbicides reduced suspected resistant (SR) kochia density only slightly or not at all compared to the untreated check. In the Minot soil, SR kochia density generally did not differ between flumioxazin and the untreated check; however, sulfentrazone generally reduced SR kochia density more than flumioxazin. Dry

weight: In both Fargo and Minot soils, sulfentrazone and flumioxazin reduced the susceptible check dry weight to nearly zero. In the Fargo soil, both herbicides reduced SR kochia dry weight significantly in the first run of the study (though not as much as the susceptible check), but only slightly in the second run compared to the untreated check. In the Minot soil, SR kochia dry weight generally did not differ between flumioxazin and the untreated check; however, sulfentrazone generally reduced SR kochia dry weight more than flumioxazin. The results indicate that both herbicides are less effective on the suspected resistant kochia populations. However, it appears that flumioxazin effectiveness has been reduced more than sulfentrazone.

Creating and Employing a Geospatial Database for Monitoring Resistant Weed Populations in the Pacific Northwest. Jamie Burroughs*; Oregon State University, Corvallis, OR (107) (107)

An online interactive map and database have been created using weed population data points collected by the Pacific Northwest Herbicide Resistance Initiative group and overlaid on spatial data obtained through the federal CropScape geo-portal. The project focuses on dryland wheat production and the spatial distribution of herbicide resistant weed populations within these growing regions. Collected data points from Oregon State University, Washington State University, and the University of Idaho containing information on weed species such as; GPS coordinates, time and date of collection, resistant screening results, images of populations and notes from the collector constitutes the searchable database. The data is overlaid on cereal crop rotation information. The online tools and database are updated as new resistant weed population are collected and screened. This presentation will provide an overview of how the online tools were developed and the planned use and expansion of the program.

Evaluating Chaff Lining in Canadian Cropping Systems. Breanne D. Tidemann*[1], Charles M. Geddes[2], Brett Mollison[3]; [1]Agriculture and Agri-Food Canada, Lacombe, AB, Canada, [2]Agriculture and Agri-Food Canada, Lethbridge, AB, Canada, [3]Agriculture and Agri-Food Canada, Melfort, SK, Canada (138)

Chaff lining is considered one of the 'big 6' methods of harvest weed seed control. While commonly utilized in areas of Australia, this is the first test of efficacy in Canada. Chaff lining abilities were established at 3 research stations of Agriculture and Agri-food Canada: Lethbridge and Lacombe, Alberta and Melfort, Saskatchewan. Each location chaff lined crops in 2021 and 2022 that included wheat, canola, peas, barley and fall rye. Pouches of 5 weed species were placed either underneath or beside the chaff lines in the fall, and removed for viability testing the following spring. Weed and crop emergence within and outside of chaff lines was measured in the following spring. In addition, greenhouse pot experiments were established with all of the above crops to determine chaff amounts required to reduce germination of wild oat or volunteer canola. In nearly all cases, any effect of the chaff on weed seed viability was an increase in viability of those seeds that overwintered within the chaff line. The exception was kochia under pea and wheat chaff where viability was reduced. Crop emergence in most cases did not significantly differ within or external to the chaff line area, however, in all cases emergence was numerically lower in the chaff lines. Weed emergence was not significantly affected by being within or external to the chaff

line area, however, in nearly all cases weed emergence was lower in the chaff line area. Low levels of chaff in pot experiments stimulated germination, likely as a result of moisture conservation. These preliminary results indicate some potential and some negative consequences of incorporating chaff lining into Canadian cropping systems. Chaff lining does not appear to reduce weed seed viability, but to present a physical barrier to weed emergence.

Smooth Scouringrush (*Equisetum laevigatum*) Control in Direct-seed Pacific Northwest Cropping Systems with Residual and Non-residual Herbicides. Mark E. Thorne*, Drew J. Lyon; Washington State University, Pullman, WA (139)

Smooth scouringrush is persistent in some dryland farming regions of the Pacific Northwest where growers have adopted direct-seed or no-till farming practices. Smooth scouringrush is a deep-rooted perennial that can form dense stands of round, leafless stems rich in silica. Stems interfere with field operations and during harvest can stain chickpea seed coats. Furthermore, smooth scouringrush at high densities can reduce crop yield. Chlorsufuron is effective on smooth scouringrush but persists in the soil and can damage sensitive crops planted too soon following application. Glyphosate at high rates can be effective but has no soil persistence. We applied chlorsulfuron and glyphosate, each alone or in tank mixes. Glyphosate was applied at 1267, 2522, and 3788 g ae ha^{-1} while chlorsulfuron was applied at 0.8 g ai ha^{-1}. Treatments were applied in July 2020 to smooth scouringrush stems growing in no-till fallow phases of farm-specific crop rotations near Dayton and Steptoe Washington. The Dayton site was on a 40% slope, the Steptoe site was in a basin floodplain. The experimental design was a randomized complete block with four replications per treatment in 3 by 9.1-m plots. Initial control was assessed visually as the percent of nontreated plots 15, 30, and 45 days after treatment (DAT). Prolonged control was assessed by counting stems in two 1-m quadrats per plot 1, 2, and 3 years after treatment (YAT). Initial control with 2522 and 3788 g ae ha^{-1} rates of glyphosate plus chlorsulfuron at Steptoe exceeded 90% by 30 DAT but was only 51% and 65%, respectively, at Dayton. Chlorsulfuron 3 YAT controlled stem density 99% and 86% at Steptoe and Dayton, respectively. Control 3 YAT with only glyphosate at 3788 g ae ha^{-1} was 99% at Steptoe but only 54% at Dayton. Visual control ratings 45 DAT were correlated with control 3 YAT at both locations, suggesting that greater initial control is associated with greater prolonged control.

Pre and Post-Emergent Use of Flumetsulam in Clover Grown for Seed. Kyle Roerig*[1], Nicole Anderson[2]; [1]Pratum Co-op, Salem, OR, [2]Oregon State University, Aurora, OR (140) (140)

Flumetsulam is a new herbicide option for producers of red, white, and crimson clover seed in Oregon and Washington. Flumetsulam is a Group 2, ALS inhibitor that controls several important weeds occurring in clover seed fields, such as Brassicaceae species, dock species (pre and early-post timings only), and mayweed chamomile. The current label allows for pre and early post applications at 0.66 oz/a, and post-emergent applications at 1.33 oz/a on red clover. Only post-emergent applications at 1.33 oz/a are allowed on white and crimson clover. Pre and early post-emergent applications offer significant weed control advantages over post-emergence applications. Additionally, clover species with more limited acres, such as berseem and balansa, are also not included on the label. Trials were conducted to evaluate crop safety and weed control of flumetsulam on white clover at pre and early post-emergent timings. In both trials the post

emergent application currently allowed by the label resulted in greater crop injury, 25-30% injury, than the pre-emergent applications, 5-8% injury. In berseem and balansa clover post-emergent applications of flumetsulam at 1.33 oz/a were evaluated. Crop injury was 15% and 8% in berseem and balansa, respectively. Seed yield was equivalent to the untreated for both species. Flumetsulam at this timing provided 100% control of mayweed chamomile and shepherd's purse. Prickly lettuce control was only 19%.

Rotational Crop Response to a Novel Cereal Mixture of Tolpyralate and Bromoxynil. Rory Degenhardt[1], Joseph Yenish*[2], David H. Johnson[3], Ryan M. Humann[4], Kevin G. Falk[5], Cody J. Chytyk[6], Jamshid Ashigh[7], Laura Smith[8]; [1]Corteva Agrisciences, Edmonton, AB, [2]Corteva Agrisciences, Billings, MT, [3]Corteva, St. Paul, MN, [4]Corteva Agriscience, Fargo, ND, [5]Corteva Agriscience, Oak Bluff, MB, Canada, [6]Corteva Agriscience, Saskatoon, SK, Canada, [7]Corteva Agriscience, London, ON, Canada, [8]Corteva Agriscience, West Lorne, ON, Canada (141)

Tolvera™ is the newest post-emergence cereal herbicide developed by Corteva Agriscience in partnership with ISK Biosciences Corporation. Tolvera herbicide is a convenient liquid formulation containing the Group 27 active ingredient tolpyralate and the Group 6 active ingredient bromoxynil. Tolpyralate is a novel active ingredient in cereals, and the sensitivity of rotational crops typical of the Northern Great Plains, where rainfall can be limiting or cool soils can persist for extended periods of the year, has not been well characterized. Between 2019 and 2022, small plot field research trials were established across the Northern USA and Western Canada to evaluate safety of rotational crops planted 10-12 months after an application of tolpyralate herbicide at various rates. No significant crop injury or yield loss were detected in any of the rotation trials, and results confirmed that many crops, including lentils (*Lens culinaris*), chickpeas (*Cicer arietinum*), canola (*Brassica napus*), field peas (*Pisum sativum)*, soybeans (*Glycine max*) and flax (*Linum usitatissimum),* can safely be planted the season after treatment. Tolvera herbicide will be an excellent tool for the safe management of hard-to-kill weeds in cereals crops and will give farmers across U.S. cereal producing areas the flexibility to choose whatever rotational crops fit with the production, sustainability and stewardship goals they have for their operations. ™® Trademarks of Corteva Agriscience and their affiliated companies or their respective owners.

Russian Thistle Cooperative Management. Judit Barroso*[1], Stewart B. Wuest[2]; [1]Oregon State University, Adams, OR, [2]USDA-ARS, Adams, OR (142)

Russian thistle (RT; *Salsola tragus* L.) is one of the few weed species responsible for most tillage and herbicide use after wheat harvest and during fallow in the winter wheat - fallow cropping systems of the semi-arid Pacific Northwest (PNW). Most dryland growers in this region are dealing with significant and increasing difficulties controlling RT due to glyphosate-resistant populations. Those who tackle the problem relatively successfully every year still have to deal with the uncontrolled RT infestation of their neighbors or on roadways next year due to the seed dispersion of this weed by tumbling. No-till farming is on the verge of becoming cost prohibitive in this region with the current level of RT pressure. In 2020, we initiated a study to see if managing the RT cooperatively could help reduce infestations and management costs. We evaluated RT infestations in six fields surrounded by cooperative areas (CA) (areas farmed by growers

committed to good RT control), and in six fields outside of the CA that were farmed by the same growers and with the same level of control, but that were surrounded by others fields with different levels of RT control. Russian thistle evaluations per year were conducted by driving the perimeter of the twelve fields using a visual evaluation of four levels (none, low, moderate, and heavy infestation). Results after three years indicated that cooperative management reduced infestations in crop and fallow fields and, on average, reduced RT treatment costs in fallow fields by $18/ac.

POST Emergence Broadleaf Weed Control in Sorghum Sudangrass. Clint W. Beiermann*; University of Wyoming, Laramie, WY (143)

Sorghum sudangrass hybrids (*Sorghum bicolor x Sorghum bicolor var. sudanense*) can be an option for forage growers who are interested in producing high biomass yields from an annual forage species. In the western US growers plant sorghum sudangrass in mid to late May. POST applied herbicides can be a useful tool in controlling weeds that emerge following planting. An experiment was conducted near Lingle, WY in 2023 to evaluate broadleaf weed control and crop safety provided by herbicides labeled for use in sorghum sudangrass. Predominate weed species at the experiment site included: common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), and hairy nightshade (*Solanum villosum* L. Mill.). Herbicide treatments were applied POST at the sorghum sudangrass V2 growth stage. Herbicide treatments included: 2,4-D ester, dicamba, 2,4-D ester + dicamba, fluroxypyr, bromoxynil, dicamba + bromoxynil, 2,4-D ester + bromoxynil, and 2,4-D butyrac. A non-treated and hand weeded check were also included. 2,4-D ester 840g ai ha^{-1} and 2,4-D ester 420g ai ha^{-1} + dicamba 280g ai ha^{-1} caused the highest crop injury, near 25%, at two weeks after application. However, crop injury was not affected by herbicide treatment at four weeks after application. Sorghum sudangrass height was reduced by the 2,4-D ester 840g ai ha^{-1} treatment at four weeks after application, and the effect remained up to crop harvest. The treatments dicamba 560g ai ha^{-1}, 2,4-D ester 420g ai ha^{-1} + dicamba 280g ai ha^{-1}, and dicamba 280g ai ha^{-1} + bromoxynil 280g ai ha^{-1} provided 95% control or greater of the predominate broadleaf weed species present at the experiment site, at four weeks after herbicide application. The herbicide treatments dicamba 280g ai ha^{-1} + bromoxynil 280g ai ha^{-1}, and dicamba 560 g ai ha^{-1} increased sorghum sudangrass biomass yield, compared to the non-treated check.

IronGate Is a New Pre-mixture of Flucarbazone and Pyroxsulam for Weed Control in US Wheat. Ryan S. Henry*[1], Ryan Bryant-Schlobohm[2], Nathan Popiel[3], Kathleen Seitzinger[4], Cody Gray[5]; [1]UPL NA Inc., Fort Wayne, IN, [2]UPL NA Inc., Amarillo, TX, [3]UPL NA Inc., Bismark, ND, [4]UPL NA Inc., Minneapolis, MN, [5]UPL NA Inc., Peyton, CO (154)

Management of grass weed pressure in wheat is a challenge that requires an integrated approach. Herbicides are one of the tools growers can use to control weeds and optimize yield potential. Efficacy of various active ingredients can be dependent on several factors, including weed species. IRONGATE Herbicide is a novel tool developed by UPL to help optimize post-emergence herbicide applications for wheat growers. IRONGATE Herbicide is a unique combination of two complimentary active ingredients - flucarbazone-sodium and pyroxsulam. This combination builds upon each active ingredient's strengths, providing high level control of green and yellow foxtail,

barnyardgrass, wild oats, bromus. spp., Persian darnel, mustard spp., and variety of other grass and broadleaf weeds. IRONGATE Herbicide is currently anticipating EPA registration.

Grassy Weed Control in Winter Wheat with Imazamox and Quizalofop-p-ethyl. Cody F. Creech*[1], Amanda C. Easterly[2]; [1]University of Nebraska, Scottsbluff, NE, [2]University of Nebraska, Sidney, NE (155)

Control of grassy weeds in winter wheat continues to be an issue for wheat producers due to limited herbicide options for in-season control. Herbicide tolerant wheat technologies such as Clearfield® and CoAXium® are available for wheat producers to use post-emergence to apply imazamox (for Clearfield®) and quizalofop-p-ethyl (for CoAXium®) for grass weed control. The objectives of this research were (1) compare jointed goatgrass control using imazamox and quizalofop-p-ethyl, and (2) to evaluate application parameters that may improve grassy weed control.

Weed Seed and Plant Control with IR and Visible Light. Joan Campbell*; University of Idaho, Moscow, ID (156)

A harvest weed seed control tool, the Weed Seed Destroyer, is being developed. Directed energy in the form of mid-range infrared energy (IR) and high intensity LED blue light are used to kill weed seeds contained in the chaff of a combine similar to impact mills. Seed and chaff are exposed for several seconds at an intensity 20 times that of sunlight. The combination of IR energy and light affects cell structure that controls radical growth. The seed is unable to produce a seedling. This technology is a non-chemical approach stop or reduce the growth of herbicide-resistant weed seeds. IR energy is converted from thermal heat in this system. Weed seed was collected at physiological maturity before crop harvest. Seed was exposed to a benchtop weed seed destroyer unit using high intensity blue light technology and heat. One dry gallon of wheat chaff (collected at harvest) was introduced into the hopper and 700 seeds of each species were placed on top of the chaff. Wild oat, downy brome, rattail fescue, Italian ryegrass, kochia, Russian thistle, and prickly lettuce were tested. Treatments included two levels of IR energy (300 F and 350 F thermal conversion) with blue light. Chaff and seed were run through the system with no light or heat as nontreated check. Chaff and seed collected were mixed with potting soil and placed in flats in the greenhouse. Emerged seedlings of weeds and wheat (seed contained in the chaff) were counted. The design was a completely randomized block with four replications. Downy brome, rattail fescue, Italian ryegrass, prickly lettuce, Russian thistle, and kochia were controlled (100%) at the highest energy level tested. The reduction of wild oat and volunteer wheat seedlings grown compared to nontreated was about 85% at the highest level tested. All broadleaf weeds were controlled 100% at the lower level tested. Downy brome, rattail fescue, and Italian ryegrass control were 84, 88, and 86% with the lower energy tested, respectively. Wild oat and wheat control was less than 50% with the lower energy tested. Modifications to increase control are under investigation.

Pre-emergent Herbicides for Low Desert Guayule. Oli G. Bachie*; University of California Agriculture and Natural Resources, Holtville, CA (157) (157)

Guayule (*Parthenium argentatum*) is a perennial desert shrub commonly grown as a source of natural rubber production, which is mostly found under the plant bark. The crop is said to be less intensive on fertilizers and irrigation water. With its adaptation to high heat, and high temperature environment, its drought resistance and salt tolerance, guayule could be an alternative economic crop for the Imperial Vally. However, the crop requires weed management, particularly during its early growth stages. While Bridgestone intends to extend guayule production to California's Low Desert, there are not Guayule registered herbicides. To help the industry and Bridgestone register desirable herbicides, we conducted research to assess weed suppressing efficacy of selected pre-emergent and incorporated herbicides and their safety to Guayule. The herbicides were tested at two rates of application and compared to a no weed control treatment. Three of the tested herbicides showed strong suppression while two of them did not show significant differences from the untreated control. Weed suppression potentials of the pre-emergence herbicides were not affected by herbicide rates of application. All herbicides showed none / minor phytotoxicity to guayule.

Screening Post Emergence Herbicides for Annual Grass Control in Grass Seed Production. Beth Fowers*[1], Brian A. Mealor[2], Donna K. Harris[1]; [1]University of Wyoming, Sheridan, WY, [2]University of Wyoming Sheridan Research and Extension Center, Laramie, WY (158) (158)

Perennial grass seed producers must manage weeds to reduce impacts to seed yield and quality. Contamination can lead to higher cleaning costs and potential rejection of product. Annual grass weeds are particularly challenging in perennial grass seed fields because limited options exist for postemergence control and mechanical removal during seed conditioning is difficult. A series of experiments were conducted to screen potential postemergence herbicides for their ability to control annual grasses while minimizing damage to nontarget grasses. Initial greenhouse screenings of 14 different herbicides on seedlings of eight desirable perennial grasses and four invasive annual grasses was conducted. Herbicides that resulted in high mortality of annual grass seedlings and low mortality of perennial grass seedlings were then used in field screenings. In 2022, replicated trials were established in existing seed production fields of six perennial grass varieties with six different spring-applied herbicides (imazapic, oxyfluorfen, primisulfuron, propoxycarbazone-sodium, rimsulfuron, and sulfosulfuron) and were evaluated for visual injury and seed germinability. Of the six herbicides, propoxycarbazone-sodium and sulfosulfuron resulted in the lowest in-field perennial grass injury and seed germinability was relatively unaffected by any herbicide. In 2023, propoxycarbazone-sodium and sulfosulfuron were applied to 2nd-year stands of 15 perennial grass species on one irrigated and one rainfed location. Marked species-specific responses to the two herbicide treatments in terms of whole-plant injury and seed germinability were observed. This research highlights the challenges of annual grass control in grass seed production fields and points to the need for increased research in this area to help keep this industry viable.

Rapidicil^{TM}, a Novel Broad-Spectrum Burndown Herbicide from Valent U.S.A. LLC. Patrick A. Clay*[1], Jonathon Kohrt[2], John Pawlak[3], Garrison J. Gundy[4], Andrew Rodstrom[5]; [1]Valent U.S.A. LLC, Fresno, CA, [2]Valent USA LLC, Noblesville, IN, [3]Valent U.S.A. LLC, Spring Lake, MI, [4]Valent U.S.A LLC, Mcpherson, KS, [5]Valent U.S.A. LLC, Kennewick, WA (159) (159)

Rapidicil™ (epyrifenacil) is a novel, low-use rate PPO-inhibitor currently being developed as a preplant burndown by Valent USA LLC. *Rapidicil* demonstrates unique characteristics compared to other PPO's, as it can be translocated via both the xylem and phloem. At a rate range of 20 to 40 g ai ha^{-1}, *Rapidicil* has exhibited fast-acting broad-spectrum control of both broadleaf and grass weed species. Field and greenhouse trials conducted with *Rapidicil* throughout the Midwest and Midsouth have shown excellent activity against difficult to control weeds including Palmer amaranth (*Amaranthus palmeri S. Watson*), waterhemp (*Amaranthus tuberculatus (Moq.) J. D. Sauer*), morningglory (*Ipomea spp.*), barnyardgrass (*Echinochloa crus-galli (L.) P. Beauv*), and several winter annuals. *Rapidicil* has also been shown to have efficacy on confirmed PPO-, glyphosate-, and ALS-resistant weed species. Currently, commercialization of *Rapidicil* is focused on preplant burndown uses in corn, canola, soybean, wheat, and non-crop uses. It is recommended that *Rapidicil* be utilized as part of an integrated weed management strategy including the use of cultural practices and multiple modes-of-action to mitigate the development of resistance. *Rapidicil* is currently under review and pending EPA registration.

Integrating Unmanned Aerial System (UAS) Imagery with Ground-Based Spot Spray Application Technology. Pete Berry*; Oregon State University, Corvallis, OR (160)

Unmanned aerial systems (UAS) technology has been utilized across various agricultural fields, from pest scouting to crop health assessment and yield predictions. However, effectively integrating the information obtained from UAS imagery into management strategies has posed significant challenges. As geographic information systems (GIS) technology is incorporated into agricultural equipment, machinery can be linked to harness the spatial information obtained from UAS imagery that enables precise management prescriptions. In this study, the efficacy of spot spraying polygons identified within UAS imagery was evaluated by integrating shapefiles into the control system of a tractor equipped with real-time kinematic (RTK) technology. The findings underscore the potential for linking GIS-enabled agricultural machinery with aerial imagery to implement precision management strategies. However, further efforts are required to streamline the synchronization of multiple RTK units.

Nozzle Selection and Application Methods for Optimal Weed Management in Specialty Crops Utilizing Trellis. Milos Zaric*; University of Nebraska - Lincoln, North Platte, NE (161)

The craft beer industry's growth has stimulated a rising demand for locally sourced ingredients, prompting the creation of hop farms across the US. Effective weed management within specialty crops with trellis systems is critical for maintaining the quality and quantity of hop yields. A notable lack of specific guidance exists for growers concerning herbicide application, especially when selecting nozzles to achieve desired spray bands of 61 to 122 cm. This study aimed to simulate pattern deposition within plant rows. The experiment assessed four nozzle types (AI8004, AIUB8504, AI9504EVS, and AI11004) with three nozzle spacing and boom height combinations (25.4 cm, 50.8 cm, and 76.2-cm) using a horizontal spray table for pattern analysis. The results showed that wider fan angles, higher boom heights, and increased nozzle spacing relative to the row middle resulted in broader spray bands. The observed broadening in spray bands may result in dose reduction delivery and foster herbicide resistance development. Notably, the AI8004 nozzle displayed inconsistent performance across various nozzle spacing and boom height

combinations across all the nozzles tested. In contrast, the AIUB8504EVS nozzle showed versatility, particularly at nozzle spacings and boom heights of 50.8 and 76.2-cm, effectively maintaining the targeted band. This research underscores the critical role of nozzle selection and configuration in optimizing spray applications. To achieve uniform spray deposition within plant rows using trellis systems, it is crucial to implement the optimal nozzle spacing and boom height for selected nozzles, ensuring uniform product application.

WSWS PROJECT 4: TEACHING AND TECHNOLOGY

Various Dicamba Thresholds in Soybean. Luka Milosevic*[1], Amit J. Jhala[2], Jon Scott[2], Stevan Knezevic[3]; [1]University of Nebraska - Lincoln, Department of Agronomy and Horticulture, Lincoln, NE, [2]University of Nebraska Lincoln, Lincoln, NE, [3]University of Nebraska - Lincoln, Concord, NE (114)

Dicamba's widespread use in dicamba-tolerant soybeans led to its increased off-target movement, impacting susceptible vegetation, including non-dicamba soybeans. This study aimed to estimate No-Observed-Adverse-Effect-Level (NOAEL), Lowest-Observed-Adverse-Effect-Level (LOAEL), and dicamba-induced visual injury thresholds for sensitive soybeans, values not previously reported in weed science literature. Threshold refers to the level of dicamba-induced visual injury that causes a specific percentage of soybean yield loss. Split-plot designed field studies were conducted in Northeast Nebraska during 2018 and 2019, utilizing 10 dicamba micro-rates and three application timings. Micro-rates, ranging from 0.0112 to 56 g ae ha^{-1}, were applied at V2, V7/R1, and R2 growth stages, simulating different drift scenarios. Crop visual injury assessments were conducted weekly up to 28 days after treatment (DAT). Additionally, growth parameters including dry matter at 28 DAT and plant height at R5, were recorded. Crop was harvested at physiological maturity and grain yield estimated. Regression analysis using the *drc* package in R software estimated various effective dose (ED) levels, presented as NOAEL (ED1 – ED2.5) and LOAEL (ED5) values. Depending on the exposure stage, NOAEL for dicamba on soybeans ranged from 0.0003 to 0.033 g ae ha^{-1}. The estimated 5% visual injury threshold values were 53% for V2, 37% for R1, and 28% for R2 soybean exposure to dicamba. While NOEAL values suggest high soybean susceptibility to dicamba, not every exposure results in substantial yield loss, as indicated by proposed visual injury thresholds. Overall, proactive measures are crucial to prevent dicamba drift and protect sensitive soybeans and other vegetation.

Invasive Annual Grasses Tech Transfer Partnership: Empowering Land Managers to Strategically Defend and Grow the Sagebrush Core. Claire F. Visconti*[1], Brian A. Mealor[2], Seth Flanigan[3], Lindy Garner[4], Mandi Hirsch[5], Jeremy Maestas[6], Jane Mangold[7], Paul Meiman[8], Andrew Olsen[9], Jordan Spaak[10]; [1]University of Wyoming, Sheridan, WY, [2]University of Wyoming Sheridan Research and Extension Center, Laramie, WY, [3]Bureau of Land Management, Boise, ID, [4]US Fish and Wildlife Service, Great Falls, MT, [5]Intermountain West Joint Venture, Lander, WY, [6]NRCS, Bend, OR, [7]Montana State University, Bozeman, MT, [8]University of Nevada - Reno, Elko, NV, [9]Intermountain West Joint Venture, Missoula, MT, [10]National Park Service, Fort Collins, CO (115)

The Invasive Annual Grasses Tech Transfer Partnership brings together scientists, educators, and land managers to bridge the gap between scientific research and on the ground management of invasive annual grasses (IAG) in the sagebrush biome. The sagebrush biome has experienced degradation across millions of acres in the past two decades due to annual grass invasion. This partnership addresses planning and management strategies for IAG through the creation of educational resources, a workshop series, and a support network for practitioners. Examples of educational resources include guiding principles that are interwoven throughout the partnership and a review of current literature focused on indaziflam use on rangelands. There are three levels of workshops, designed to create feedback mechanisms to continually refine all workshop levels. The workshops vary from a broad overview on IAG planning and management to defining and prioritizing actions in a local working group's core areas. Lastly, we have established a community of practice to provide an ongoing forum for representatives of local IAG working groups to discuss challenges and successes. Through these various components of our partnership, we are committed to listening to land managers' needs and adjusting our approaches to best meet their informational and support needs.

Protecting Freshwater Resources in the Arid West: Understanding the Impacts of Aquatic Weeds. Mirella F. Ortiz*[1], Scott J. Nissen[2]; [1]Utah State University, Logan, UT, [2]Colorado State University, Ft Collins, CO (116)

Info to add to abstract:We don't do a good job introducing our W students to aquatic weed management (southeast does it really good for obvious reasons), my teaching program includes identifying and managing aquatic weeds.We need to give our students the chance of protecting fresh water resources. I can be a resource for instructional materials, slide sets, lecture notes, live plants, (videos?)....Look at all W states aquatic weeds distribution - California!

Utilizing Hands-On Learning During In-Person Extension Weeds Schools. Jeanne Falk Jones*; Kansas State University - NW Area Office, Colby, KS (117)

Hands-on learning at meetings can be an important part of farmers and agronomy professionals maintaining attention and developing further understanding of weed science concepts. For the hands-on learning, a bingo game was implemented at the K-State Crop Pest Management Schools in December 2023. This game included bingo spots with specific questions, topics to be covered or phrases that speakers would use. On the evaluations from the near 150 attendees, many attendees said one of their favorite things about the school was the bingo game. At the K-State Weed Management Schools, attendees participated in a hands-on activity utilizing the K-State Chemical Weed Control Guide. Over 125 attendees worked through the resource, learning to utilize the tables and information to make weed management decisions. When evaluating the school, over 80% of the attendees rated that session as valuable or very valuable. Another session at the weed management schools included a spray table and water sensitive paper to demonstrate different types of adjuvants. The attendees were able to see differences in spray coverage and droplet size. Several attendees listed the adjuvant demonstration with the spray table as their favorite part of the weed school. The Bingo Game, working through the K-State Chemical Weed Control Guide and seeing the visuals of adjuvants being sprayed are examples of hand-on activities that were

highly rated in evaluations by the meeting attendees and many said they would implement items that they learned during these activities.

Podcasting as a Strategy to Win the War Against Weeds. Sarah Lancaster*[1], Joseph T. Ikley[2], Alyssa Essman[3]; [1]Kansas State University, Manhattan, KS, [2]North Dakota State University, Fargo, ND, [3]The Ohio State University, Columbus, OH (118)

Podcasts are a relatively new platform that can be used to disseminate weed management information in an on-demand format. This non-traditional outlet may appeal to clients that are less willing or unable to attend traditional in-person Extension events. However, the platform has not been widely utilized by Extension weed scientists. Limited in-person meetings and attendance due to concerns from the COVID-19 required Extension weed scientists to explore new formats of information transfer. The War Against Weeds podcast was initiated in January of 2021 to increase access to weed management information for agricultural professionals in the North Central Region. Now in its seventh season, the podcast has over 41,300 downloads of over 100 episodes. Listeners are primarily from the United States and Canada, and it has also been streamed in 77 other countries. The podcast is hosted by Libsyn, which allows downloads from the podcast homepage, Spotify, iTunes, and other audio streaming platforms. Podcast episodes are recorded using Riverside.fm and edited in Adobe Premier Pro. High quality audio content is achieved using external microphones and headphones. Our experiences suggest that podcasting is an effective method for disseminating weed management information to a broad audience of farmers, industry personnel, graduate students, and crop management practitioners.

WSWS PROJECT 5: BASIC BIOLOGY AND ECOLOGY

The Influence of Rainfall on S-metolachlor Activity Applied to Wheat Residue. Olanrewaju E. Adeyemi*[1], Fernando Munaro[2], Pedro Antonio Vougodo Salmazo[2], Paulo V. Da Silva[2], Eric P. Westra[1], Mirella F. Ortiz[1]; [1]Utah State University, Logan, UT, [2]Universidade Federal da Grande Dourados, Dourados, Brazil (108)

In the state of Mato Grosso do Sul, Brazil, corn is the primary crop in the soybean rotation, but in the southern region of the state, the soybean/corn rotation is being reconsidered due to challenges such as delayed rainfall leading to late soybean planting, subsequently delaying second-season corn planting, and exposing it to frost periods, heightening risks and prompting farmers to consider alternative crops like wheat. Meanwhile, the presence of wheat crop residue poses significant challenges to pre-emergence herbicide efficacy in wheat-soybean rotations. This research conducted in June/July 2023 aimed to assess how varying rainfall amounts affect the recovery of s-metolachlor from wheat residue and the impact of different waiting periods before rainfall on s-metolachlor recovery. Using a RCBD with four replications, herbicide treatments including Dual Magnum (s-metolachlor 1,440 g a.i. ha^{-1}) and Prefix (s-metolachlor 1,035 g a.i. ha^{-1} + fomesafen 228 g a.i. ha^{-1}), were applied to 3 t ha^{-1} wheat residue. Rainfall was simulated at 0-, 4-, 7-, and 10-days intervals at 10-, 20-, and 30-mm. Results indicated that s-metolachlor recovery increased with higher rainfall amounts, with a significant increase observed from 10 to 20 or 30 mm, contributing

an additional 325 ug mL^{-1} of s-metolachlor recovery. Moreover, the waiting period between herbicide application and rainfall significantly affected s-metolachlor recovery, with the shortest wait period resulting in the highest s-metolachlor recovery rates, while longer wait times led to decreased recovery efficiency, indicating that s-metolachlor loss can be 2 times greater than recovery if rainfall is delayed.

Novel Weed Control with Low Doses of Electricity. Erik A. Lehnhoff*[1], Leslie Beck[1], Paul Neher[2]; [1]New Mexico State University, Las Cruces, NM, [2]Retired, Las Cruces, NM (109)

Alternatives to manual and chemical weed control are desired by homeowners and organic producers. Weed management via electricity is becoming a more viable option, but commercial electrical weeding systems are expensive and generally not suitable for home or small-scale use. We have developed a safe and effective system for pre-emergent weed management in xeriscaping, prevention of climbing vines, and potentially managing weeds in high-value crops. In a xeriscaping weed control experiment, electric weed control was integrated into landscaping gravel and compared to gravel alone, and electric weed control reduced weed cover by 90% compared to the gravel control. In an experiment to test the ability of electricity to prevent vine weeds from climbing structures, electricity was 100% effective at prevention, while weeds in the control climbed readily and covered 45% of the structures. In vineyards, our electric weed management system was very effective, limiting weed cover to <10% or better, and electric weed control was more effective than pre-emergent herbicide and was equal to plastic mulch. Our results indicate that electricity is a viable alternative to manual, mechanical or chemical methods for weed control in xeriscaping and in prevention of climbing weeds, and can manage weeds in select cropping systems.

Evaluation of Intermediate Wheatgrass (*Thinopyrum intermedium*) Herbicide Tolerance. McKenzie J. Barth*, Andrew R. Kniss, David A. Claypool; University of Wyoming, Laramie, WY (110)

Kernza intermediate wheatgrass (*Thinopyrum intermedium*) is a perennial grass in development as a dual-use grain and forage crop. Herbicides may improve weed management in the establishment year, which is consistently reported to have high weed pressure. Breeding Kernza for increased grain yield may affect its herbicide tolerance versus intermediate wheatgrass, along with other characteristics associated with crop domestication. A greenhouse experiment was conducted to evaluate herbicide effects on intermediate wheatgrass germplasm. Six herbicides (2,4-D, clopyralid, dicamba, metsulfuron, pinoxaden, and propoxycarbazone) were applied at 4 rates to 6 Kernza varieties and 3 intermediate wheatgrass varieties. Herbicides were applied to plants at the 2 to 3 leaf stage. Plants were harvested for above and belowground biomass 4 weeks after herbicide application. Biomass was dried for 48 hours at 60? and weighed to the nearest milligram. Kernza varieties responded differently to herbicides compared to the other intermediate wheatgrass varieties in total biomass ($P = 0.008$) and belowground biomass production ($P = 0.004$). Kernza appeared to be more sensitive to clopyralid and 2,4-D than other intermediate wheatgrass varieties. In the absence of herbicides, intermediate wheatgrass produced a higher root to shoot ratio than Kernza with no difference in total biomass production, and this subtle difference may explain differential tolerance to herbicides.

From Liberty 280 (Racemic Glufosinate) to Liberty® ULTRA Herbicide (L-glufosinate), Powered by Glu-LTM Technology. Rand M. Merchant*[1], Eric C. Schultz[2], ALice L. Harris[2], Marcel P. Kienle[3], Ryan B. Aldridge[2], Samuel D. Willingham[2], Ingo Meiners[2], Siyuan Tan[4]; [1]BASF, Greeley,, CO, [2]BASF, Rtp, NC, [3]BASF, Limburgerhof, Germany, [4]BASF, Cary, Nc 27519, Usa, NC (111)

Glufosinate ammonium has been utilized as a postemergence herbicide in glufosinate tolerant cropping systems for nearly 30 years. To this point, all glufosinate herbicides registered for use in the United States have been in the form of a racemic mixture, including Liberty® 280 herbicide from BASF. Racemic mixtures of glufosinate contain a 1:1 ratio of D-glufosinate and L-glufosinate enantiomers. The L-isomer of glufosinate has herbicidal activity while the D-isomer has negligible herbicidal activity as it does not inhibit glutamine synthetase (GS) the target enzyme. For years it has been known that the two enantiomers have existed together in racemic mixtures; however, a resolved isomer form of L-glufosinate ammonium has never been commercialized in the United States. Pending registration, BASF intends to launch Liberty® ULTRA Herbicide, Powered by Glu-L Technology in 2024. Liberty ULTRA herbicide is the resolved isomer of L-glufosinate ammonium, and Glu-L Technology is the patent protected manufacturing process by which the D-isomer of glufosinate is enzymatically transformed into the herbicidally active L-isomer to create a resolved isomer of L-glufosinate ammonium. Liberty ULTRA is an improved version of Liberty 280 with innovations from both chiral chemistry and formulation chemistry. Field trials were conducted from 2021 to 2023 to compare weed control efficacy between Liberty ULTRA and Liberty 280. Liberty ULTRA at 370 g ai/ha demonstrated incremental improvement in overall weed control efficacy compared to Liberty 280 at 654 g ai/ha. Field trials were also conducted in 2022 and 2023 to compare Liberty ULTRA to seeral generic racemic glufosinate products. Liberty ULTRA at 370 g ai/ha achieved better weed control than all tested generic racemic glufosinate at 654 g ai/ha. Liberty ULTRA herbicide will also feature the Liberty Lock formulation which improves spray droplet retention, increases droplet spreading and ultimately drives more active ingredient into weed leaves compared to generic glufosinate. Liberty ULTRA will have a higher L-glufosinate concentration in the formulation compared to other glufosinate formulations which enables up to a 25% reduction in application use rate when compared to Liberty 280. The application use rate reduction will mean that customers will be able to make more applications, serve more customers and cover more acres from the same tote or bulk tank compared to most racemic glufosinate herbicides. Liberty ULTRA Herbicide, Powered by Glu-L Technology and the Liberty Lock formulation represents the future of glufosinate for BASF for effective broad spectrum weed control in glufosinate tolerant crops

Effect of Different Herbicides on Soil Health in Cotton Production Systems. Jasleen S. Makkar*, Rupinder Saini, Arjun Kafle, Lindsey Slaughter, Glen Ritchie; Texas Tech University, Lubbock, TX (112)

Weeds are a major issue in cotton (*Gossypium hirsutum* L) monoculture system, reducing crop yield. Herbicides are necessary for effective weed management, but their over usage can alter soil composition, disrupt microbial populations, and enzyme activities, and can significantly impact soil health. This study evaluates the effect of different pre-emergence (trifluralin, prometryn, *S*-metolachlor, and acetochlor) and post-emergence (glyphosate, glufosinate, and dicamba)

herbicides on soil chemical properties, ß-Glucosidase enzyme (BG) activity, and cotton productivity. A field experiment was conducted at Texas Tech University in summer 2023. Different herbicides and their rates (1x and 2x) were randomized three times in a factorial randomized block design. Soil sampling was done at different intervals. BG activity was not affected by either pre-emergence or post-emergence herbicide treatments but changed significantly with time till the fourth week following each application. Prometryn and *S*-metolachlor at both rates increased the soil pH, whereas trifluralin significantly increased the soil EC compared to control. The 2x rates of pre-emergence herbicide increased the soil organic matter significantly compared to control. In pre-emergence herbicides, prometryn at both rates and *S*-metolachlor, and trifluralin at 2x rate increased lint and seed yield compared to other treatments. For post-emergence herbicides, dicamba resulted in significantly highest lint and seed yield. Also, doubling the rate of post-emergence herbicides resulted in a 16 and 13% increase in lint and seed yield, respectively. Results show that the BG enzyme activity was not affected by herbicide treatments . However, doubling the herbicide rate resulted in higher lint and seed yield.

Developing a Petri Dish Assay to Compare the Response of Pigweed Species to Residual Herbicides. Ramawatar Yadav*, Andrew R. Kniss; University of Wyoming, Laramie, WY (113)

Annual pigweeds such as waterhemp (*Amaranthus rudis*), Palmer amaranth (*Amaranthus palmeri*), and redroot pigweed (*Amaranthus retroflexus*) are troublesome weed species in sugarbeet production systems. Previous research conducted across the regions has reported variable levels of pigweed species response to residual herbicides. Since presence and emergence of these three species rarely overlap in the same fields in the future, studies on the relative effectiveness of residual herbicides are challenging. We are evaluating the feasibility of using a petri dish assay to rapidly and reliably predict the pigweed response to residual herbicides commonly used in sugarbeet production. Fifty seeds of each pigweed species were placed on a single layer of filter paper in separate petri dishes at a constant 24° C. A range of concentrations of ethofumesate, EPTC, acetochlor, cycloate, and metamitron herbicides were applied to petri dishes in 10 ml of distilled water. Germination response was observed daily for one week. Seeds with 2 to 3 mm radicle length (at least twice the seed size) and white root tips were considered successfully germinated. Preliminary results suggest that waterhemp was the most sensitive and Palmer amaranth was the least sensitive species to ethofumesate, EPTC, and cycloate. Redroot pigweed was more sensitive than Palmer amaranth, but less sensitive than waterhemp to ethofumesate and cycloate. Redroot pigweed sensitivity to EPTC was similar to Palmer amaranth but was higher than waterhemp. Species response to acetochlor and metamitron did not differ; but this may be due to methodological problems with these particular herbicides. These results may explain the differential control observed among pigweed species to sugarbeet herbicides, but additional development will be required to adapt this method to all relevant herbicides.

Buffering the Effects of a Changing Climate: Halophytes as a Source of Osmotic Stress Tolerance. John M. Lemas*[1], Philip Westra[1], Eric L. Patterson[2], Todd A. Gaines[1]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI (119)

Land managers are experiencing increased occurrences of environmental stresses that impact food production across the United States. These stresses include excessive heat or cold, drought, and

salinification. Russian thistle (*Salsola tragus*) is an allotetraploid tumbleweed that has adapted to a wide range of environments and is problematic in both cropping systems and rangeland. Research has been performed to inform agronomists on control tactics for this species, but we have yet to investigate how this species is so resilient to osmotic stress. We screened a Russian thistle population for resistance to 37ºC, 4ºC, 200 mM NaCl, drought, and nutrient stress for 28 consecutive days. We collected biomass and surface area metrics were taken from both root and shoot tissue for each of these trials. Results for the cold and salt treated samples were not statistically different from their controls, so we selected these two stresses for an expression analysis to investigate this lack of stress response. We extracted RNA from salt-treated plants at 0, 3, 8, and 24 hours after treatment (HAT), and from cold treated plants at 0, 6, and 24 HAT. We preformed differential expression analysis in DESeq2 for each tissue type and treatment. The differentially expressed genes that we identify will further our understanding of osmotic stress response in plants. This understanding could present potential genetic mechanisms for increasing osmotic stress tolerance in desirable crop cultivars.

Factors Affecting the Management of Aminopyralid Residues, a Persistent Herbicide Used for Invasive Plant Management in Alaska. Gino Graziano*[1], Zachary Redman[2], Brant Woodruff[3]; [1]UAF Cooperative Extension Service, Anchorage, AK, [2]University of Alaska Anchorage, Anchorage, AK, [3]University of Alaska Fairbanks, Anchorage, AK (120)

The persistence of any herbicide is problematic when it impacts desirable vegetation. However, herbicide persistence can also be very useful when extended control of a seedbank is needed. The persistence of aminopyralid has been surprising to some because it is highly mobile in water, indicating it should leach with runoff rather than bind to soils. In subarctic soils, aminopyralid persists for many years after application leading us to wonder if the studies of persistence at lower latitudes were not applicable to Alaska. Our labs recently conducted tests of the ability of aminopyralid to bind to soils from Southcentral and Interior Alaska. We discovered a pH dependence on the ability of aminopyralid to bind to soils, where highly acidic conditions (pH<4) cause aminopyralid to bind more readily to soil particles. Even though Alaska has soils with a generally lower pH, typically in the pH 4-5 range, field tests indicate that aminopyralid remains bioavailable in treated soils for several years after treatment. The pH dependence leads to other hypotheses as to how aminopyralid persists in soils, and some solutions to explore for remediation when persistence is no longer desirable.

Investigating Dicamba Resistance in Kochia Populations from Colorado. André Lucas Simões Araujo*, Jacob S. Montgomery, Todd A. Gaines; Colorado State University, Fort Collins, CO (121)

A survey on dicamba resistance was conducted in sugar beet-growing regions of Colorado, focusing on kochia populations. The objective of this study was threefold: to create a resistance distribution map, investigate potential target-site resistance mechanisms, and test cross-resistance to an herbicide mixture containing dicamba, 2,4-D, and dichlorprop in populations classified as dicamba resistant. Populations were categorized based on their survival, where under 2% is susceptible, between 2% and 19% is low resistance, and over 20% is resistant. A known marker for dicamba resistance located at the degron region of the *AUX/IAA16* gene was employed. The

AUX/IAA16 gene was sequenced to verify the presence of the $G_{127}N$ substitution in the degron region among dicamba survivors. A dose-response curve was generated in a population that survived at a field rate of the auxin herbicide mixture. Nonlinear regression log-logistic model with three parameters was employed in data analysis. Three populations showed no mutation at this site, indicating the involvement of different and novel resistance mechanisms. One kochia population exhibited a splicing variant at the degron region of the *AUX/IAA16* gene. The auxin herbicide mixture provided good control of all dicamba-resistant populations, except for population A5, which did not have mutations at the degron region of the *AUX/IAA16* gene. Our findings suggest a likely novel resistance mechanism within kochia populations. Further research is crucial to deepen our understanding of resistance mechanisms, to generate markers for early resistance detection, and to develop effective weed management strategies to prolong the utility of the current management tools.

Germination, Ecology, and Herbicide Resistance Status of Palmer Amaranth and Common Waterhemp in the Central Valley of California. Anil Shrestha*[1], Kelsey Galvan[2], Takui Frnzyan[2], Katherine Waselkov[1]; [1]California State University, Fresno, CA, [2]California State University, Fresno, Fresno, CA (122)

The invasiveness and resistance to several herbicides have led Palmer amaranth (*Amaranthus palmeri*) and common waterhemp (*A. tuberculatus*) to be ranked as the worst agricultural weeds in the US. These species have been present in California cropping systems for at least a decade but have not been as problematic as in other parts of the US. However, in recent years, they are becoming more prevalent and difficult to control with commonly used herbicides in annual and perennial cropping systems in the Central Valley. A glyphosate-resistant (GR) population of Palmer amaranth was confirmed in the Valley, and ALS-resistant populations of both species have been confirmed in the Valley. Some Palmer amaranth plants escaped the label rate of glyphosate and rimsulfuron but were adequately controlled by other postemergence herbicides such as glufosinate, paraquat, saflufenacil, and tank mixes. Germination, competitiveness, and genetics of both these species, including the GR and glyphosate-susceptible (GS) types of Palmer amaranth, were also studied. Alternative postemergence herbicides such as glufosinate, rimsulfuron, and caprylic+capric acid provided good control of common waterhemp, when applied at the 4-6 leaf stage. Glyphosate resistance has also been confirmed genetically in one Valley population of Palmer amaranth, and ALS resistance mutations have been detected in common waterhemp in two Valley populations. Germination of GR and GS Palmer amaranth seeds to environmental stresses such as moisture, salinity, and pH were similar, however, the GR plants were more competitive than GS plants with young grapevines. Both Palmer amaranth and common waterhemp seeds were moderately tolerant to drought but highly tolerant to salinity, and germination was greater in neutral to alkaline than in acidic conditions. However, the plants were not very tolerant to salinity past the germination stage, as growth and survival was impeded beyond 10 EC. This study showed that there are GR and ALS-resistant Palmer amaranth, and only ALS-resistant common waterhemp populations yet, in the Central Valley. Both species have the potential to germinate in dry, saline, and alkaline soils, but may not grow very well under these conditions.

GST Inhibition - Influence on Quizalofop P-ethyl Metabolism in Winter Wheat. Amber Pelon*; Colorado State University, Fort Collins, CO (123)

Weed competition has the most significant negative impact on wheat grain yield relative to other pests. Understanding the contribution of metabolism in overall resistance to herbicides can lead to new methods for controlling weeds in wheat. This research assessed the role of Phase 2 plant cell metabolism in quizalofop P-ethyl (QPE) tolerance in winter wheat (Triticum aestivum) by GST activity. We hypothesized that the addition of a safener would make the wheat more tolerant to the herbicide while the addition of a GST inhibitor would make the wheat more sensitive to QPE. Experiments were conducted analyzing the QPE effect on whole-plant biomass and an LC-MS/MS analysis of the amount of quizalofop acid (QZA) found in plant extracts. Safeners enhanced herbicide metabolism which increased CoAXium wheat tolerance to QPE. GST inhibitors, conversely, decreased herbicide metabolism causing CoAXium wheat to be more sensitive to QPE. Understanding the contribution of metabolism in overall resistance to herbicides can lead to breeding improvements for more herbicide-tolerant wheat varieties and new methods for controlling weeds in wheat.

Kochia and Russian Thistle: Two Tumbleweeds in a Pod? Philip Westra*[1], Todd A. Gaines[1], Eric L. Patterson[2], John M. Lemas[1]; [1]Colorado State University, Fort Collins, CO, [2]Michigan State University, East Lansing, MI (124)

Abstract not Available

Russian Thistle Seedbank Longevity and Seedling Emergence in Oregon. Fernando H. Oreja*[1], Jennifer Gourlie[2], Nicholas G. Genna[2], Judit Barroso[1]; [1]Oregon State University, Adams, OR, [2]Oregon State University, Pendleton, OR (125)

Russian thistle (*Salsola tragus* L.) is among the most troublesome weeds in cropland and ruderal semiarid areas of the Pacific Northwest (PNW). Understanding the emergence and seedbank longevity of this broadleaf weed is crucial for growers in the region to develop a successful integrated weed management program. The goal of this study was to characterize *S. tragus* seedbank persistence and emergence in fallow and spring wheat fields in the PNW. A completely randomized block design was established in four sites, two in 2020 and two in 2021, with four replications at the Columbia Basin Agriculture Research Center (CBARC), Adams, OR. The number of *S. tragus* seedlings was recorded throughout the four-year experiment. *Salsola tragus* seeds emerged during the four years, with the highest emergence rates in spring wheat (72%) and fallow (32%) in the first year. Emergence was significantly lower beyond the first year, and timing of emergence was delayed in years 3 and 4 compared to year 1. Seedling emergence began in late March and early April for the first two years, while it started in late April and May for the third and fourth years, respectively. The findings indicated that *S. tragus* emerges mainly the year after dispersion and that its emergence lasts approximately two months. This study underscores the importance of *S. tragus* control in the first year to substantially reduce the seedbank and prevent reinfestations.

SYMPOSIUM: ESA, How Got Here and Potential Implications

EPA Perspective. Rebecca Perrin*; EPA Region 8, Denver, CO (150)

Abstract not Available

U.S. Forest Service Perspective. Daniel Tekiela*; U.S.D.A. Forest Service, Lakewood, CO (151)

Abstract not Available

Colorado Department of AG Perspective. Les Owen*; Colorado Department of Agriculture, Broomfield, CO (152)

Abstract not Available

Questions and Discussion. Alan Helm*; Gowan, USA, Walla Walla, WA (153)

Abstract not Available

SYMPOSIUM: Palmer Amaranth in the West

Origin Stories: Hypotheses for the Rise of Palmer Amaranth. Kelsey C. Brock*; University of Wyoming - Plant Sciences, Laramie, WY (162)

Abstract not Available

Impacts of Palmer amaranth to the dry bean Industry. Jerry Haynes*; Jacks Bean Company, Denver, CO (163)

Abstract not Available

Impacts of Palmer amaranth to the sugar beet Industry. Rebecca Larson*; Western Sugar Cooperative, Denver, CO (164)

Impacts of Palmer Amaranth to the Seed Industry. Laura Pottorff*; Colorado State University, Ft Collins, CO (165)

Abstract not Available

State of Palmer Amaranth Resistance in the West. Todd A. Gaines*; Colorado State University, Fort Collins, CO (166)

Abstract not Available

Management of Palmer Amaranth the West. Nevin Lawrence*; University of Nebraska, Scottsbluff, NE (167)

Abstract not Available

DISCUSSION SESSIONS

Project 1 Discussion Session: Pasture, Range, Forestry, and Natural Areas

Moderator: Rachel Seedorf

Notes prepared by: Jaycie Arndt

Topic: *What is the role of modern innovation tools for invasive plant species management on non-cropland environments.*

Drones:

- Joe Swanson: Aerial applicators are concerned about application safety and coverage which makes drones safter for difficult application areas and it decreases drift potential
- Dan Tekiela: 'Drones are the future' is what everyone thinks. But there is a struggle to find universal role that they are the right choice.
    - Where are drones the best option (replace backpack sprayers, replace aerial applications)?
    - Remote detection may be more important that herbicide application.
- Leslie Beckworth: In Teton County, WY they use drones for steep aspect/slopes. It increases application speed and lower cost/acre. Having the technology to avoid obstacles is needed and it requires pre-mapping. The pre-mapping is easier than carrying a backpack sprayer on steep slopes.
- Shannon Clark: It's getting harder to get aerial applicators to get licensing complete, but it's easier to get drone pilot licenses so we may have more drone pilots available.
- Sandra MacDonald: Brought attention to the aerial applicators needing a commercial aerial application license for pesticide safety requirements.
- Claire Volk: Having the right drone for the project is necessary
    - Mapping
    - Grass app
    - Shrub app
    - Avoiding fence rows/ telephone lines.
    - We don't want to replace all aerial helicopter applications but we can replace a lot in lower flights/ windy areas
- Lars Anderson: Sublette County Weed and Pest has used a spray drone for small applications (5-10) acres of even coverage. An ATV may take hours, but a drone can cover the same area in <1 hour.
    - Tim Prather: Are they ^ using real time detection or post processing?
    - Lars: Using it for immediate treatment polygons
    - Chloe Mattilio: How are you working with FAA restrictions
    - Lars: There is a blue list for FAA exemptions.
        - CSU drone school is helpful, but not required.
        - Their drone company helped with process to get FAA exemption (Park 137 Ag Exemption)
- Patty York: There are more people interested in drone applications than carrying backpacks as field crews, so drones may improve summer weed spraying capacity

- Derek Sebastian: There is limited research on application specifics with drones. Some companies are 'overselling' efficacy results. Nozzle technology may be behind still. There needs to be more research to get good coverage and effective set ups for application.
- Craig Alford: While there are a lot of drone pilots, not many of them are interested in learning how to properly apply pesticides.
- Cody Beckley: A discussion at WSSA brought up the concern that research may need to go back to square one to determine best practices for drone application. Things like efficacy, nozzles, droplet sizes, boom sizes, etc)
- Patty York: Detection of certain species is still hard from drone imagery.
- Tim Prather: Question about post processing of drone imagery.
    - Chloe: Learning post processing and drone work is difficult. It requires time and training. You can't get classified species maps without someone to train the models.
        - Decreased pixel size leads to exponential increase in data management.
    - Tim: Recognition of species can be better with multi-spectral imagery
    - Chloe: Yes, but we're (range and forestry land managers) are not the target audience in drone aerial imagery.
    - Lars Anderson: Real time mapping works if you know what to look for (dependent on species). You can draw a treatment polygon in the field using landmarks (manual classification). Post processing isn't needed if the goal is immediate management instead of modeling.
- Tim Prather: what does 1 day of flying look like for post processing?
    - Chloe: Use one battery for one area, to prevent changes in imagery. One battery can cover ~ 11 acres in about 20 minutes. Post processing: it takes 6 hours to build the mosaic of imagery. Then you manually classify values for the prediction model which takes a couple hours. For pixel prediction, you can use R studio or Google Earth Engine, which is faster as long as you have the right inputs.
    - Rachel Seedorf: Can you use the models in other settings?
        - Chloe: Sometimes. Drones differ which makes it hard to compare models from different drone imagery.
        - Tim: Calibrating imagery from different flights is hard, different drones is harder.
- Brian: Manual classification is different than mapping classification. There is a gap of knowledge/ discussion with drone companies and we should share more as a scientific community with what we need to get successful models.
- Derek Sebastian: Sometimes satellite imagery is better for some species. Invasive annual grasses seem to be a good target from satellite imagery currently.
- Scott Nissen: Should we have a symposium next year?
    - Small acreage vs. large acreage use.
    - Utah Weed Management Association- a presentation was given about using drones to blow herbicide onto cliff sides.
    - Drones are used in aquatic herbicide applications already.
    - Dan Tekiela: This symposium could bridge the gap between all WSWS projects.
    - Byron Sleugh: Have a regulatory review (backpacks vs drones)
    - Sandra MacDonald: Risk assessment component should be included.
- Lar Anderson: Pointed out that drones were designed for flat croplands, so we should see adjustments to better capabilities in rough landscapes and technology improves.

- Sanda MacDonald: Posed question about using composting as an option for weed management?
    - Tim Prather: There are papers about specific species that survive composting, but they're limited.
        - Research stems from thermal death curves using solarization or bio fumigation studies.
    - Byron Sleugh: Be careful to keep herbicide use in mind when planning to do composting. Could have movement of herbicide into compost materials.
- Nick Race: Using apps for plant ID and more
    - INaturalist
    - Dan Tekeila: EddMaps is creating a pipeline between EddMaps and INaturalist .
    - Kelsey Brock: Both are great for invasive species that aren't as notorious
        - This info can be used for weed risk assessments
        - Incorporating citizen science is important to growing the data we can use.
- Jake Courkamp will be the Pasture, Range, Forestry, and Natural Areas Moderator at the 2026 meeting.
- Rachel Seedorf concluded the discussion.

Chair 2024:
Rachel Seedorf, Aero Applicators, Inc.
rachel@aeroapplicators.com

Chair-Elect 2025:
Jaycie Ardnt, University of Wyoming Extension, Sheridan, WY
jarndt1@uwyo.edu

Chair-Elect 2026:
Jake Courkamp, Colorado State University
jacob.courkamp@colostate.edu

List of Attendees not available.

Project 2 Discussion Session: Weeds of Horticultural Crops

Moderator: Elizabeth Mosqueda

Topic: *How can we help growers increase profitability in the next 10 years – opportunity and needs for research and extension?*

Summary:

There are issues with overlapping herbicide SOA's. There's an urgency with growers and research/extension agents for new chemistries in horticultural crops. The movement of palmer into these systems might change this and show urgency for the matter.

Spray application technology is also an important matter. It's as if the industry is going back to "pre-glyphosate" era. This is challenging for those who have never had to manage weeds without it. This is why it's important to help growers utilize the other tools they have in a better way. Personnel is always a challenge when managing weeds in horticultural crops, too.

We need to decipher the idea of trying to get people to be realistic with management expectations and lowering thresholds, especially as it related to markets. We need to be ok with the idea of living with a few more weeds and potentially reducing treated areas (exp. 50% vs 30% treatment). When it comes to the cost of weed control in horticultural crops, it is mostly with application, therefore, how can we help reduce the numbers of tractor passes for application? Chemigation is also promising as the overall cost of application can be significantly lower. If we push for practices such as cover crops this could allow for a spray strip that is more narrow and targeted for weeds.

Labor is probably still the biggest issues within weed control of horticultural crops. The cost for producers to hand weed is still significant, and is only predicted to increase as years progress. This on top of not seeing new herbicide MOA's makes things incredibly challenging in these systems. There was the idea of looking back at old chemistries and utilizing them in new ways, for example, with Kerb in leafy greens, its standard practice now to use this through chemigation because of how effective it is. The agrochemical industry is trying to bring in new chemistries for these crops, but there are a lot of challenges on top of these specialty crops not being a large enough market.

Elect New Chair-Elect
-Nominations:
Craig Alford – Corteva

Chair 2024:
Elizabeth Mosqueda, Madera Community College
elizabeth.mosqueda@scccd.edu

Chair-Elect 2025:
Clint Mattox - USDA
clint.mattox@usda.gov

Chair-Elect 2026:
Craig Alford – Corteva
craig.alford@corteva.com

Attendees:

Pamela Hutchinson	Craig Alford
Jesse Richardson	Brad Hanson
Kat Caswell	Rohith Vulchi
Aaron Becerra-Alvarez	Ram Singh Ima
Rui Liu	Brian Schutte
Clint Mattox	Elizabeth Mosqueda

Project 3 Discussion Session: Weeds of Agronomic Crops

Moderator: Joseph Mettler

Topic: *Use of Precision Technology in Research*

Notes: By Hayden Lee and Joseph Mettler

Discussion Summary:

- See and Spray technology
  - Use of robotic sprayer to identify and differentiate between grass grown for seed and the grassy weeds with in the field and spray all in the same pass with the sprayer
    - Use of AI to develop the model and select the grass weeds to spray. Correct 90% of the time.
- Talk of using the WeedIt system, Bosch Sprayers
  - Spot spray technology with dual boom systems
  - Industry is years ahead of University systems
    - Industry and COOPs are to the point where they are confident in the ability to identify and spray the weeds in a dual boom and dual tank system.
      - They are to the point were they are maximizing efficacy by asking extension agents, what the pH of the two tanks should be.
  - Talk of the benefits are really for rapid contact herbicides, as small/emerging weeds will often get missed so a secondary pass is needed 10-14 days later. If translocating herbicides are used, unfortunately the weeds would get sprayed again during the second pass as they are often still green.
  - An example was made of how farmers will use variable rate systems so that larger or more dense patches of weeds would get sprayed with a higher concentration or volume of the herbicide for better control. But this often times led to rather high rates (perhaps even off label). Said Farmer in the example which back to a standard broadcast boom sprayer because it ended up being the cheaper route.
- Discussion switched to drones
  - There are specific companies starting up with fleets of drones to spray invasive weeds in rangeland systems. They either spray field sections by just using GPS or they with spot spray by in time visible aerial imagery.
  - It was noted that universities would need to rely on other professionally trained computer science, engineers etc to really get involved in the precision ag side of things. The standard agronomy trained individual just isn't enough anymore. The university or private groups that are going the research have separately hired personal.
  - Drone technology is changing so much from year to year that universities are unable to fund or have the resources to keep drone technology updated from year to year.
  - The question arose: Does drone application get labelled similar to aerial applications?
    - It was mentioned that drone spray application are not legal in Canada because the labels do not specify such an application. Aerial application is different.
      - It was also noted that there is some work being done in Canada to utilize satellites to be able to identify Kochia patches for example. Down to a specific weed type.

- Use of technology to increase research program efficacy
    - Autosteer
- It was mentioned that it would be beneficial to have individuals who are more involved in the precision ag to reach out to and invite the more technically trained individual to come to the WSWS to give presentations on some of this stuff. But also as a resource to ask questions to during the breaks. Pete Berry and Charlie Hicks know individuals within their company or programs that could provide a lot of insight, especially from the industry side of things since they are so much more advanced than the universities. Perhaps a Symposium on Precision Ag if we could get enough of these other individuals that could attend.

Section Election For Chair Elect:

Pete Berry motioned to elect Kyle Roerig section chair elect of the Weeds of Agronomic Crops
Ian Burke seconded the motion
Voting on the motion was unanimous in the affirmative

Joseph Mettler will continue as Chair and moderator at the 2024 annual meeting

Chair 2024:
Alix Whitener, FMC
alix.whitener@fmc.com

Chair-elect 2025:
Joseph Mettler, North Dakota State University
joseph.mettler@ndsu.edu

Chair-elect 2026:
Kyle Roerig, Pratum Co-op
kroerig@pratumcoop.com

Attendees:

Ryan Rapp - Bayer	Nevin Lawrence – Nebraska
Zari Dobrev – TeeJet	Jeanne Falk Jones – K-State
Sarah Lancaster – K-State	Joe Ikley – NSDU
Codee Lee – CHS	Hayden Lee – CHS
Brian Jenks – NDSU Minot	Kasey Schroder – UNC
Pete Berry – OSU	Andy Branka – OSU
Kyle Roerig Pratum Co-op	Ian Burke – WSU
Roland Schirman – Retired	Breanne Tidemann - AAFC
Kirk Howatt – NDSU	Joseph Mettler - NDSU

Project 4 Discussion Session: Teaching and Technology

Moderator: Kirk Howatt, Chair

Topic: *So you want to start a podcast?*

The Teaching and Outreach Discussion Session started at about 4:50 pm, right after the completion of the oral paper presentations. The final paper was "Podcasting as a Strategy to Win the War Against Weeds" by Sarah Landcaster of Kansas State University. This paper was placed at the end of the session to serve as a primer for the discussion topic, "So You Want to Start a Podcast."

Before the discussion commenced, nominations were opened for the next chair-elect of the section. Sandra McDonald expressed interest in the position and accepted the nomination. No other nominations were received, and Sandra was elected without objection.

Sarah Landcaster was the only attendee who had coordinated and facilitated a podcast. Most others in attendance have been guests on a podcast. Podcast experiences had been with recorded/edited sessions. There was awareness of some podcasts that operate live but the tension of saying something inaccurate or delays in responses lead most to favor a recorded session that can be slightly edited before posting. The after session editing really doesn't need to be that involved if one doesn't want to invest a lot of time in that operation.

One benefit of a live podcast would be option of call in questions and comments, but that opens a risk of inappropriate rogue calls and loss of control of a message or topic, if that is the structure. Screening calls would require additional personnel and perhaps more elaborate equipment. A suggestion was discussed of how there could be request for questions either called in or submitted online or via email with the intention of responding during a later podcast. They could even become the topic of an entire podcast.

Equipment needs are really not that extraordinary. External microphones are quite necessary but the expense doesn't need to be more than about $25. Other equipment can be upgraded but, again, not that necessary. So other than the online access, there is minimal expense.

Turnaround of edited podcasts can happen within the day as edits often are quite minor. They have stopped trying to fit in a particular time frame but 45 minutes is a good guideline. Time needed for specific topics generally ranges from 25 to 60 minutes. They send a few questions to guests ahead of time to keep the discussions on track but allow for tangents and sideline discussions.

Spring field season is a difficult time to develop and record podcasts. Consideration needs to be given to spring topics that can be recorded at other times of the year for posting at time-appropriate release. Topics come from grower questions, podcast discussions, academic material, timely Extension updates, and public service announcements. Sarah's podcasts are also publicized through the WSSA. She was also suggested to visit with WSWS Publications for promotion.

During the discussion, there was a sideline discussion of games to assist learning and attention retention at meetings. The previous presentation was "Utilizing Hands-On Learning During In-Person Extension Weeds Schools" by Jeanne Falk Jones. Bingo cards have been used by a few. Some have the bingo square items be actual learning components others had used non-instruction material just as attention checks. For online trainings in Colorado, instructors need to confirm

presence every 5 minutes. This is accomplished mainly with true/false questions. Question stems are constructed to be true confirmations of training material to assist formative assessment rather than summative assessment for certification. They just need to demonstrate presence. Another option was construction of Jeopardy boards.

The discussion concluded at 5:30 pm.

Chair 2024:
Kirk Howatt, North Dakota State University
kirk.howatt@ndsu.edu

Chair-elect 2025:
Harlene Hatterman-Valenti, North Dakota State University
h.hatterman.valenti@ndsu.edu

Chair-elect 2026:
Sandra K. McDonald, Mountain West Pesticide Education Safety
sandra@mountainwestpest.com

Attendees:

Sandra McDonald	Mountain West Pesticide Education Safety
Leslie Beckworth	Teton County Weed & Pest
Tim Prather	University of Idaho
Sarah Lancaster	Kansas State University
Greg Dahl	Retired from Winfield Solutions/WSSA President
Jeanne Falk Jones	Kansas State University
Harlene Hatterman-Valenti	North Dakota State University
Kirk Howatt	North Dakota State University

Project 5 Discussion Session: Basic Biology and Ecology

Moderator: Alex Ceseski

Topic: *Weed Management in 2040: Will Novel Biological Interventions Play a Role?*

The discussion began with a conversation on RNAi, jumping off some comments one of the participants made in their talk in the session. They suggested a symposium on some of our problem weeds and how we might utilize some of the genetics to improve crops but also to design biologics such as RNAi. The group discussed whether RNAi is truly an attainable goal for weed science. It was acknowledged that there has been success in other areas such as insect and pathogen management and that there is investigation into combining RNAi with nanoparticles for better absorption and efficacy, but currently nothing close to market ready that we are aware of.

There was a discussion about biologics being used for diseases and nematodes in the industry and lots of work on allelopathy but the struggle seems to be in how to bottle it or make it work. There was a discussion on using biologics such as inoculants or seed treatments that don't directly target weeds but make crops more vigorous.

Gene drives were discussed that it has been tried in palmer but has been inconsistent in terms of efficacy as far as the participants were aware. There was agreement that there is lots of basic biology work still needed for sterile males and gene drive type techniques.

There was a discussion on insects for weed management, basically an introduction from the host range of the weed and that it can be effective but is more applicable for management in natural areas compared to annual cropping systems. This led to some discussion of the interface of noxious/invasive weeds and wildfires, and the increased frequency of wildfires in recent years. A question was asked on if there are anymore bioherbicides available for some of the higher value specialty crops and it was agreed that there wasn't.

There was a discussion that there is work done in Canada and the US that suggests that yield loss from weeds is not due to resource depletion or competition primarily, but an evolutionary response to neighbour recognition and light quality changes. The suggestion was made that if the biology work was done to figure out how to turn off that response, we could highly improve our crop yield because they simply wouldn't respond to the presence of the weeds, or we may only have to do a relatively easy strategy like mowing to keep them shorter than the crop. To do this though a crop specific focus would be needed. We need to be breeding varieties for weed response too, with breeding selections made under weed pressure to improve varietal ability to withstand competition. It's an interesting dichotomy with pathogen management where genetic resistance is often the primary recommendation with fungicides being a secondary tactic; in comparison, weed management often relies on herbicides first and varietal 'resistance' to the impacts of weeds isn't an available trait for producers to select.

There was some discussion around endogenous compounds and why we aren't enhancing them and some of the difficulties around that. Additionally, the importance of reviving work on managing and stimulating the weed seed bank to grow was discussed. Some ongoing work on pyroligneous acid was mentioned. There was also speculation on whether we could use seed coatings as protection or safeners for herbicides that might otherwise cause injury.

The final reflection was on the fact that in the future, the regulatory environment will likely favour the development of more biological tactics compared to chemical herbicides.

The new chair elect is Albert Adjesiwor.

Chair 2024:
Alex Ceseski, University of California
arceseski@ucdavis.edu

Chair-elect 2025:
Breanne Tidemann, Canada Agriculture and Agri-food Canada
breanne.tidemann@canada.ca

Chair-elect 2026:
Albert Adjesiwor, University of Idaho
aadjesiwor@uidaho.edu

Attendees:

Breanne Tidemann	Phil Banks
Kirk Howatt	Wyatt Freeze
Courtland Richards	Albert Adjesiwor
Andy Branka	Greg Dahl
Shahbaz Ahmed	Aaro Esser
Andrew Kniss	Carl Coburn
Jasleen Makkar	Phil Westra
Jenna Meeks	Jill Schroeder
Lisa Jones	Alex Ceseski

Discussion Session: Education and Regulatory

Moderator: Jane Mangold

Topic: *Communicating the Complexities of Weed Science and Management in an Age of Information Snippets.*

These discussion notes are not verbatim but are intended to provide a summary of the discussion that took place.

The discussion session began with Dr. Mangold presenting a brief overview of the current complicated environment of communicating Weed Science to stakeholders. Namely that Weed Science and management is complex, site specific, interdisciplinary, and information often is nuanced and needs to be contextualized. However, stakeholders often want straightforward answers, easy-to-implement solutions or specific products, and quick results.

This overview led to the first question for discussion: ***Is this a fair assessment of the situation?***

Participants in the section agreed that often there is a conflict of information, which depends on the goals of each party. Addressing stakeholder needs might mean going through intermediaries ―land managers, agronomists, salespersons, ect…―, who may have different set of goals then either the stakeholder or weed scientists. Further, conflicts can also arise between neighboring stakeholders who might share different management goals and values.

And while participants in the discussion generally agreed with Dr. Mangold's assessment of communicating Weed Science, there was also agreement that some stakeholders do seek out as much detail as possible to address their situation. Other times a stakeholder thinks their question is simple when it is in fact quite complex. A number of participants in the discussion session pointed out that public community forums are a great opportunity for discussing complex management issues and exposing differences in goals and values among stakeholders.

The second question Dr. Mangold asked was: ***Who are our stakeholders and customers?***

In terms of agronomic Weed Science, agronomists or farm advisors are becoming more common as stakeholders; as these intermediaries may be elevating difficult problems and challenges to weed scientists rather than directing farmers to the subject matter experts. Farmers may not appreciate the contribution of university extension professionals in addressing their concerns as they may be unaware that extension professionals were ever contacted. Some in the room considered this lack of direct contact with "on the ground" stakeholders as a challenge, while other thought of intermediaries as an opportunity to multiply their impact. Further, when discussing university extension, which is historically constrained to within state lines, a lot of current extension is occurring outside the states where a professional is employed.

The third set of questions asked was: ***How do you navigate these discrepancies?***

- ***Share approaches that have worked/not worked?***
- ***How do you know if something worked/didn't work?***

Many of the participants in this section of the discussion who spoke worked in public land management, from county governments, state governments, and the National Park Service. One participant noted that in his area a lot of the public is not receptive to chemical weed control and confrontations are common in the public space. Another participant also had similar negative interactions in the past with public stakeholders. Both agreed that the most important strategies. for addressing conflicts is to not argue or become confrontational, and to focus on staying in a "service" mentality when interacting with the public.

Among university extension professionals, it was agreed by many that when trying to address challenging and complex topics, communicating small amounts of information at a time, and using a lot of repetition of that information can be an effective strategy regardless of the media used.

The final question asked was: ***How do we "package" weed science and management information to be more effective?***

This last question led to several good examples of teaching survey techniques, herbicide resistance management, and other Weed Science knowledge to clientele in the form of a hands-on workshops. This discussion exposed that there is often a lack of good examples of how information can be communicated in extension. From this point, the idea was discussed of developing a future symposium on communicating Weed Science to stakeholders. Such a symposium could be focused on presentations on sharing previous science communication successes or could invite experts to walk symposium audience members through various mock workshops. Submitting titles and abstracts within the Teaching & Technology and Education & Regulatory sections of WSWS was also encouraged.

Chair 2023:
Jane Mangold, Montana State University
jane.mangold@montana.edu

Chair-elect 2024:
Nevin Lawrence, University of Nebraska-Lincoln
Nlawerence2@unl.edu

Attendees at the Education and Regulatory Discussion Section

Name	**Email**
Jane Mangold (Chair)	jane.mangold@montana.edu
Nevin Lawrence (Chair-Elect	nlawerence2@unl.edu
Phil Banks	marathonag@zianet.com
Jill Schroeder	jischroe1@gmail.com
Tim Prather	tprather@uidaho.edu

AJ Mondor	ajmondor@canyoncounty.id.gov
Cody Beckley	cody.beckley@usu.edu
Dirk Baker	dbaker@campbellsci.com
John Coyle	jcoyle.oz@mail.com
Rachel Seedorf	rseedorf@yahoo.com
Jeanne Falk Jones	jfalkjones@ksu.edu
Chuck Wilcox	cwilcox@allisare.com
Jake Courkamp	jacob.courkamp@colostate.edu
Alex Stoneburner	alexandra_stoneburner@nps.gov
David Clements	clements@twu.ca
Corey Ransom	corey.ransom@usu.edu
Ian McRyhew	ianmcryhew3@gmail.com
Lesley Beckworth	lbeckworth@tcweed.org
Brad Hansen	bhanson@ucdavis.edu
Kai Umeda	kumeda@cals.arizona.edu
Kelsey Brock	kbrock5@uwyo.edu

WSWS BOARD OF DIRECTOR'S BOARD POST ANNUAL MINUTES (2023)

WSWS Annual Business Meeting 2023
WSWS Board Meeting Minutes -- DRAFT
Boise, Idaho March 2, 2023

Thursday March 2, 2023- Room 110D Boise Centre West

Board Meeting

In attendance – Sandra McDonald, Clarke Alder, Joel Felix, Greg Dahl, Alan Helm, Marcelo Moretti, Dirk Baker, Ryan Rapp, Tim Prather, Nevin Lawrence, George Newberry, Curtis Rainbolt, Aaron Becerra-Alvarez, Eric Gustafson, Mirella Ortiz, Eric Westra and Brad Hansen

Welcome and Introductions

The meeting was called to order at 12:05 by Curtis Rainbolt, WSWS President 2023-2024. Curtis thanked everyone for staying after the meeting to attend the Board of Director's post meeting.

Curtis asked the attendees to introduce themselves.

Final Meeting Attendance- *Eric Gustafson*

Curtis thanked Eric Gustafson, WSWS Business Manager, for keeping thing going with WSWS and for all of the help he provided in the past few months.

Eric reported that 275 people registered through the registration system.

Post 2023 Annual Meeting debrief lead by *Curtis Rainbolt*

The BoD discussed the meeting and reported that there were not a lot of complaints; but many of us did hear very good things about the venue. A "shout out" was offered to the Boise Center Security lady; everyone agreed she was a highlight.

Boise was declared to be a great place to meet. Great to have walkable restaurants of all price ranges and options.

Big picture – the Boise Center staff was great to work with facility and food was good.

Ryan Rapp – Be sure there is water in the meeting rooms - especially for the speakers

We need to remind the moderators that if they finish early DO NOT move the time up

Need a large room for Range, Forestry

Ryan – the Student lunch was tight - maybe give them some more time?

Dirk Baker - WAPMS students were interested in joining WSWS in the future.

Discussed thoughts on future WSWS/ WAPMS joint meetings – the consensus was that it is a good fit for both Societies. Possibly meet together every 3-4 years.

President-elect update – *Tim Prather*

Tim Prather started a discussion about the 2024 WSWS Program.

Nevin Lawrence stated that combining Teaching & Technology and Education & Regulatory

Curtis – agrees that T&T & E&R is tough to schedule due to low numbers of papers

Greg Dahl – suggests that Tim P effectively combine T&T & E&R at Denver meeting

Tim Prather – addressed the idea of combining the sections is a good idea

2-3 symposium ideas may be coming from today's Discussion sections

Bio-control interest

Tim wants to look at doing a strategic symposium based on what will succeed in Denver

Look at a single day registrations - register for the symposium and a day free

Discussed the extra burden of having a single day registrations

Single day or a workshop registration

SRM did an every morning plenary - Tim thought it was a good draw – Greg D says that the Canadians do it as well and their Plenary sessions are full as well. Have a very focused topic and with a panel discussion/ or a QA Discussion sections kind of like an interview – the Canadian Plenary sessions are advertised

Weed Genomics

Palmer Amaranth Symposium - would draw a lot from local Crop Consultants. Not a lot of people working on Palmer in the west - who could we draw?

Tim Why discussion only today - Brad Hanson & Alan Helm reported that the Discussion sessions were very well attended

Tim questioned if we are getting enough submissions to have a program on Thursday

Should we have a 20 minute talk

We could have a 30 minute break rather than 15 minutes – longer breaks will be beneficial and possibly ending at 4:30.

How long for lunch has to do with access to food – give people tijme for logistics

Brad - Plenary sessions could be built into a 30 minute invited paper

Mirella mentioned using an online voting system for student voting – Aaron said the students are talking about it

Eric mentioned that students could have a speaker – maybe on Federal hiring

Brad - getting more agency and local folks – getting more of a practitioner talk in the sections – 3 research talks and then a farmer/manager talk

Alan – inviting someone to talk about drone technology Ryan thinks it can come as a symposium

Practitioner type talk – lean on the project chairs

Task them with also finding a potential speaker to invite during the session

We had a request for a virtual session - the cost would have been an additional $1000

Who in Denver can build on our sessions – Ryan

Curtis reminded Tim that the BoD would give him support and could provide a sounding board

Tim – increasing our agency attendance, Tim and Julie have 3 Forest Service and 2 BLM individual committed to participate on a facilitated discussion Zoom call. In some cases there has been a lot of turnover in the agencies – could we offer some kind of a professional training to provide them an incentive to attend?

How is SRM getting more agency people involved – weed people get capped at GS 7 so it is a structural problem thus will have less support to travel

The discussion transitioned the Joan Campbell's request at the Business Meeting that WSWS Committees meet in person at the WSWS Annual Meeting.

Remind the membership that they are able to attend committee meetings.

Have committees post meetings time and information on WSWS Website

We do have a calendar function

Committee meetings Zoom vs in-person

If you want your committee to meet in person - then should we add it to the WSWS Meeting Program?

What would it be beneficial to have a WSWS online committee meeting a week or so before the meeting? That would also facilitate getting the reports done.

Do a pilot with some committees.

Greg says that WSSA contacts Committee chairs to ask if they want to meet in person, but they prefer having a Zoom meeting.

Constitution and Operating Procedures Representative – *Sandra McDonald*

Sandra said she would begin the updates of the Operating Procedures by going through the previous BoD Meeting Minutes to be sure that all approved changes have been incorporated. Then she will contact the committees and work with them to determine and address any need procedure updates/clarifications.

Summer BOD meeting date selection-Denver

Curtis will develop 2 or 3 approaches to the Summer BoD meeting. Nevin suggests putting things in the Newsletter.

Date for the Summer BoD meeting at the Grand Hyatt come in on a Tuesday and meet all day Wednesday with wrap-up on half-day on Thursday.

Shooting for week of July 10 or 17 – Eric will work with the Grand Hyatt and let the BoD know the dates, ASAP.

New Business:

A reminder that the Weed Contest is the week of July 24

Adjourn

Curtis asked for a motion to adjourn. Lots of moves and seconds to adjourn – 1:15 pm. The vote to adjourn was unanimous.

The minutes were recorded by Sandra McDonald on behalf of Joe Vassios.

WSWS BOARD OF DIRECTOR'S SUMMER BOARD MEETING MINUTES (2023)

Grand Hyatt Denver
Denver, Colorado
July 20-21, 2023

Thursday, July 20, 2023

Grand Hyatt Denver - Crystal Peak C – 2nd floor or by Zoom meeting

Welcome, call to order, and approval of agenda– *Curtis Rainbolt*

Call to Order: President Rainbolt called the meeting to order and for approval of agenda at 8:0 AM Mountain.

Attendees: Tim Prather, Joe Vassios, Clarke Alder, Aaron Becerra-Alvarez, Kenzie Barth, Carl Coburn, Mirella Ortiz, Marcelo Moretti, Eric Westra, Sandra McDonald, Ryan Rapp, Alan Helm, Joel Felix, Nevin Lawrence, Curtis Rainbolt, Greg Dahl, Albert Adjesiwor, Eric Gustafson

Officer Reports

Secretary – Joseph Vassios Approval of minutes from May BOD meeting

- *Minutes to be amended during the finance committee report and addressed later in this meeting*

Constitution and Operating Procedures Representative - *Sandra McDonald*

- *Operating guide has been reviewed and edits for formatting and consistency of terms.*
- *Incorporation of passed edits to ensure all are included in the document.*
- *Edits have been shared with the Board for review.*
- *Edits will change "Guide" to "Procedures"*
- *Update to remove references of "mailing to business manager"*
- *Suggest updating hard dates for deadlines. Marcelo suggests a date or time period that could be referenced.*
- *Will update "Board of Directors" to "Board" after the first mention.*
- *Need to incorporate the responsibilities of the Society to WSSA to ensure continuity on committees/reports.*
- *Motion that the Constitution and Operating Procedures Representative can update the Guide based on the discussion and update based on the Style Guidelines.*
    - *Motion: Nevin Lawrence*
    - *Second: Greg Dahl*
    - *Discussion: Joel indicated to ensure award deadlines and guidelines are stated.*
    - *Passed unanimously.*

Business Manager Report – *Eric Gustafson*

- *Business Manager report is redundant with Finance, Program and other committee reports.*
- *Operating Procedures states that report is due, so would need to be amended.*
- *Agreement among the Board that this ongoing report isn't needed since it is*

redundant.

Treasurer Report – *Ryan Rapp*

- Treasurer report much the same as the Finance Committee report.
- Ryan suggests that the Treasurer report include the financial statements, and finance committee meeting minutes will be the committee report.

Finance – *Ryan Rapp* **–** chairperson and board contact

- *Annual finance committee meeting*
- *Account Balances:*
    - *Checking: $53561.46*
    - *Money Market: $50596.58 in money market*
    - *CD: $105,460.84*
    - *Investments: $207,638.36*
    - ***Total Assets: $417,257.25***
- *Frank Vargas, new financial planner, gave advice. So shorter term CDs are doing better than long term. Goal was to get 1 to mature each year. 2 will be up for renewal in October. Will renew for 1 yr to take advantage of higher interest rates. Old RBC was higher risk. New fund suggested is 7-8% historically, so committee is supportive. Would be a gradual shift to the new American Funds Portfolio*
- *$417,257.25 current funds*
- *Recommendations for Board Action:*
    - *Committee recommends we update fees for large companies to $1,500, and smaller companies*
      $1,000
    - *Sandra suggests another tier for small companies to contribute.*
    - *Other discussion about possible ways to define small vs. large companies by employee number, revenue, etc.*
    - *Vote will be tabled for Sustaining Member discussion.*

President – *Curtis Rainbolt*

- *Renewed IMI Contract*
- *Discussed and renewed social media contract with Amy Giannotti*
- *Seattle Westin 2025 contract has been signed*
- *Met with Lee and other Regional and National Weed Science Presidents on Capitol Hill to advocate for priority issues*
- *Working on appointing members to committees*
- *Curtis has been attending Finance Committee Meetings*

Past President– *Joel Felix*

- *Working on 2023 meeting proceedings*
- *On Past President Nominations Committee for WSSA.*
- *Diversity and Inclusion Committee suggests Past President reviews Code of Conduct with President Prior to Annual Meeting that after meeting the Code of Conduct Complaints are reviewed by Past President following the Annual Meeting. Those found in violation could face violations.*
    - *Who would investigate complaints?*
    - *Supportive of incorporating these into the guidelines.*
    - *Need to review guidelines of other societies to refine. Suggest sending*

back to committee for future consideration at our next meeting.

President Elect/Program Chair – *Tim Prather*

Tim proposed some change to the program schedule. Posters sessions should continue to be in the morning

Research Section Chair – *Marcelo Moretti Reported*

Education and Regulatory – *Nevin Lawrence*

No written report needs to be submitted, but suggest to include on in operating guide. Suggest adding symposia call as part of responsibilities.
Add to the position the role of organizing and reviewing all symposia submitted.

- *Motion by Nevin*
- *Second by Tim Prather*
- *Passed with all votes.*

Mr. President dissolved the symposium committee.

Member-at-Large Public – *Erik Lehnhoff*

Member-at-Large Private – *Clarke Alder*

Reported that he believes the position could be more active on the board.
Suggested to reach out to crop consulting organizations.

WSSA Representative – *Alan Helm*

Reported that WSSA BOD meeting will be in San Antonio TX on Sept 5-7
Review what progress on the Strategic Goals during an upcoming meeting.

Student Liaison – *Aaron Becerra-Alvarez*

One team from OSU and one from UC Davis will attend the national contest. One from Idaho. After the conference, survey was sent to students for feedback
Vanelle Peterson will gift a WSWS history book to student winners along with a plaque.
Update the scholarship application and website and send the application to the responsible parties.

- *Responsible parties to be identified.*

Aaron will communicate with students to identify volunteers to join committees. Send info to Mr. President Curtis Rainbolt.

CAST Representative – *Greg Dahl*

Represented WSWS in CAST working group Worked with CAST WSSA representative
Collaborated on a new CAST issue paper on invasive plants and fire.

Proposal to re-organize WSWS projects ad-hoc

Andrews Kniss proposed a reorganization of WSWS Projects.. The group discussed the pros and cons.

No motion was made.

Tim Prather was inspired and made three motions. Seconded by Nevin Lawrence.

Motion 1. Change the Basic Biology and Ecology project name to Basic Biology, Ecology, and Technology. Discussion was held and voted. Greg Dhal abstained.

Motion passed.

Motion 2. Change the Teaching and Technology Transfer project name to Teaching and Outreach. No discussion

Motion passed.

Motion 3. Create a new project to be named Regulatory and Policy

Sandra motions that the newly created project, Regulatory and Policy, and the newly named, Teaching and Outreach project be moved under Education and Regulatory section.

No discussion. Motion passed.

Nevin Lawrence 12:14 PM

Basic Biology, Ecology, and Technology

Research Section (chair on BoD)	Education & Regulatory Section (chair on BoD)
Agronomic Crops	Teaching & Outreach
Range, Forrest, & Natural Areas	Regulatory & Policy
Basic Biology, Ecology, & Technology	
Horticultural Crops	

The meeting resumed after lunch at 1:05 pm local time.

Discussion of 2023 Annual Meeting, Program Committee report continued – *Tim Prather*

General session:

A Topic for the general session – parks and recreation.

Honoraria – it is possible to cover the costs of the invited speaker. **Water issues in Colorado Basin –** the group is based in Denver. **Other ideas proposed:** no specific suggestions**.**

Meeting Theme? Not necessary.

Committee Reports:

Publications Committee (Tim Prather – board contact) Proceedings – ***Carl Libbey***
Carl is working on it. *Excellent work.*

WSWS Newsletter – *Carl Libbey*
Carl is working on it. *Excellent work.*

Research Progress Reports – *Traci Rauch*

Should it continue-viable? Discussion on the viability and historical changes of its relevance.

Motion: Sandra makes a motion to terminate it.

- Alan Helm seconded it.
- Discussion: none
- Vote passed.
- Ryan Rapp abstained because he would like it to be discussed by the general audience.

Website – *Eric Gustafson*

Nothing to report.
Update recent award winners.
Update the form to indicate the year a person is a char and the year one is rotating off. Keep info about future meetings.

Local Arrangements – *Eric Westra* – chairperson (Tim Prather – board contact)

Reported that he recruited help in Denver as he is now in Utah. Also moved the poster easels to Colorado.

Director of Science Policy – *Lee Van Wyche*n *Reported on various activities during the year*.

Nominations – *Pat Clay* – chairperson (Joel Felix – board contact)

Report sent by Pat Clay.

Public Relations – ***Mirella F Ortiz*** – chairperson (Nevin Lawrence – board contact)

Mirella worked with Sandra to update Public Relations Operating Procedures

Create a photographer ribbon.

Send an invitation to the general membership asking who would be willing to take pictures in exchange for the meeting registration. The photographer must attend all events, edit the pictures, and select the one for publication.

Motion to approve the recommendation from the committee to update procedures with changes to 1a.Social media manager contract is subject to the president approval.

- *Motion by Tim Prather*
- *Second by Greg Dahl*
- *No Discussion*
- *Passed unanimously.*

Fellows and Honorary Members – *Rich Zollinger* – chairperson (Joel Felix – board contact)

Report submitted by Zollinger.

Site Selection – *Kyle Roerig* – chairperson (Curtis Rainbolt – board contact)

The proposed sites were discussed, and Eric will request updated quotes from Albuquerque, NM and San Diego. A follow-up voting electronically.

Awards – *Harry Quicke* – chairperson (Curtis Rainbolt – board contact)

No report was received.

Poster – *Lovreet Shergill* – chairperson (Tim Prather – board contact)

No report was received.

Student Paper/Poster Judging – *Alix Whitener* – chairperson (Tim Prather – board contact)

Report received. Sandra brought up some suggestions not included in the committee's report. A change in scoring terminology and grading was proposed. (Sandra has the edits)

- Motion to have the wording change around the oration in the evaluation form.
- Motion from Alan Helm
- Second from Tim Prather
- No Discussion
- Motion passed unanimously

Changes stand and will be communicated back to the relevant committees.

Necrology – *Lesley Beckworth* – chairperson (Joseph Vassios – board contact)

Sustaining Membership – *Carl Coburn* – chairperson (Joel Felix – board contact)

Carl presented his report. A discussion was held on increasing sustain members and the fees. Ryan Rapp suggests that we improve the way sponsors are recognized.

The committee will make a proposal to the board.

Legislative – *Ryan Edwards* – chairperson (Alan Helm – board contact)

Report submitted, no requests.

Herbicide Resistant Plants – *Stephen Valenti* - chairperson (Clarke Alder – board contact)

Reported submitted. Clarke will develop the printing material with the committee as a graphical designer.

Meeting adjourned at 4:45 pm local time.

Friday, July 21, 2023

Meeting called to order by President Curtis Rainbolt at 7:55 am local time.

WSWS History Committee Ad-Hoc – Vanelle Peterson committee is dissolved, but Vanelle is joining us to discuss historical photos

- Vanelle explain the progress made by the now-dissolved History Committee.
- She proposes working with Kai Umeda to digitalize historical pictures to be included in the WSWS History publication.
- Motion to grant Vanelle access to have the historical information for the time required. Second by
    - Motion from Greg Dahl
    - Second from Ryan Rapp
    - No Discussion
    - Passed unanimously
- Motion to modify the operating procedure to include updating the WSWS history to the Proceeding Editor and the student chair-elect.
    - Motion from Greg Dahl
    - Second from Alan Helm
    - No Discussion
    - Motion passed
    - Note. Update both parts of the operating procedure Proceeding and Student liaison chair-elect.
- Motion to add the annual business meeting minutes to the end of the proceedings as an addendum.
    - Motion by Dirk Baker
    - Second by Ryan Rapp.
    - No discussion
    - Passed unanimously.

Dirk Baker makes a motion to add the minutes from the annual business meeting to the end of the proceedings. This requires adding them as an addendum after approval at next year's business meeting. This also means the most current proceedings will always be pending minutes.

Diversity and Inclusion Ad-Hoc Committee – Elizabeth Mosqueda (Curtis Rainbolt – board contact)

We revisited the student contest score sheet contest. No further changes were made. See notes from Thursday, July 20.

Elizabeth also inquired about the D&I material created by the committee to include the material on the website.

Invasive Species Ad-Hoc Committee – Brian Mealor/Jane Mangold (Curtis Rainbolt – board contact)

The report was submitted. No motions needed or made.

Needs of our Agency Members (Ad Hoc) – **Julie Kraft** (Curtis Rainbolt - board contact)

The report was submitted.

Reorganizing WSWS Sections & Projects (Special assignment) – Andrew Kniss (C Rainbolt- board contact)

Was discussed on Thursday

New Business:

2023 proceedings dedication – Joel Felix indicated that all proceedings should have a dedication. The 2023 still does not have a dedication.

Motion to dedicate the proceeding of the 2023 meeting to Phil Banks.

- Motion from Tim Prather
- Second from Nevin Lawrence
- No Discussion
- Passses Unanimously

"The 2023 Proceeding is dedicated to Dr. Phil Banks in recognition of his unwavering devotion and invaluable contributions to the Western Society of Weed Science over the years.".

11:30 am Adjourn

- Motion to adjourn from Tim Prather
- Second from Alan Helm
- No discussion
- Passes Unanimously

WSWS ANNUAL BUSINESS MEETING MINUTES (2024)

WSWS Annual Business Breakfast
Grand Hyatt Denver- Denver, Co
March 7, 2024

Call to Order at 6:53 AM by President Rainbolt

Welcome and Recognition of Incoming and Outgoing Officers- Curtis Rainbolt
Rotating off of the BOD: Clarke Alder, Marcelo Moretti, Nevin Lawrence, Joe Vassios
Joining BOD: Beth Fowers, Brad Hanson, Carl Coburn, Lovreet Shergill

Officer Reports

Secretary – Joe Vassios

- Presented that 2023 Annual Business Meeting Draft minutes are shared on Website, to be voted on for approval after the Officer Reports

Business Manager Report – Eric Gustafson

- This years meeting 243 attendees, 10 additional for Palmer Amaranth symposium
- Encourage earlier registration and title submission.

Treasurer and Finance Committee Report – Ryan Rapp

- Frank Vargas, financial advisor, suggested shift to a new fund that is lower risk and has more potential for returns.
- WSWS will transfer the balance of investment funds to the new portfolio over 3 years.
- Money in CD's have been shifted to short-term for better returns

President – Curtis Rainbolt

- Summer BOD meeting was held at the Grand Hyatt Denver in July 2023
- Reviewed renewal of contracts during the past year
- Secured the Westin Seattle for the 2025 Annual Meeting
- Traveled to DC with Lee Van Wychen and other Regional Presidents

Past President – Joel Felix

- As Past President, served on the Site Selection Committee
- Led the WSSA Nominations Committee - Sent nominees to WSSA President to include WSWS members to serve on WSSA Committees. Encourages WSWS members to vote for WSWS nominees to serve on committees.

President Elect/Program Chair – Tim Prather

- Oversaw the program committee and worked on assembling the program with IMI
- 167 total presentations

Education and Regulatory – Nevin Lawrence

- More presentations on Teaching and Technology Session
- None for the Education and Regulatory Session, but were able to fill this slot with the ESA Symposium

Member-at-Large Public – Erik Lehnhoff

- Eric will be working with public sector members to identify hurdles to them participating to see if the Society can assist them to increase participation.

Member-at-Large Private – Clarke Alder

- Has been working with the Herbicide Resistant Plants Committee on their tri-fold brochure. Some available at the registration desk for review

Research Section Chair – Marcelo Moretti

- Worked with session chairs to ensure any absences were covered to have representatives present for each session.
- Assisted with training session chairs.
- Updating appendix for the session chairs for more upfront information on responsibilities for session chairs

WSSA Representative – Alan Helm

- WSSA/SWSS Joint Meeting was successful. 600 total attendees and 200 students
- Next year's WSSA meeting will be held Feb 24-26, 2025 in Vancouver, BC
- Looking at 2027/2028 Joint Meeting with International Weed Science Society

CAST Representative and WSSA President – Greg Dahl

- All US Regional Weed Science Societies and WSSA are members of CAST
- Jill Schroeder was the Liaison for a CAST publication on Invasive Species
- Participated in CAST Annual Meeting in College Station Texas in Nov 2023
- New CAST President Chris Boomsa joined
- See CAST report for additional information on relevant events and publications
- Encourage individual membership to CAST
- WSSA meeting in San Antonio was successful, and encourage attendance at the 2024 meeting

Student Liaison – Aaron Becerra-Alvarez

- Kenzie will be taking over
- Weston Mock? WSU will be taking over as next Student Liaison in rotation
- Thank you to mentors who participated into Student Night Out last night
- Silent Auction closes this morning, submit last minutes by 10 AM
- Thank you to those that donated items to the silent auction

Constitution and Operating Procedures Representative – Sandra McDonald

- Working to update the Operating Procedures
- Can contact Sandra to get Procedures updated to make current and relevant
- Any officers or committee Chairs

Approval of 2023 Annual Business Meeting Minutes - Joe Vassios

- Motion to approve Meeting Minutes: Vanelle Peterson
- Second: Alan Helm
- No Discussion
- Passes Unanimously

Director of Science Policy – Lee Van Wychen

- Appropriations have stayed flat including IR-4, IPM Program, Hatch Act, were able to keep funding for some aquatics projects
- Herbicide labels - as label standards are updated, please provide feedback to Lee prior to next week to include in comments.
- Upcoming deadlines - Science Policy Fellow Applications are due April 1 & USDA NIFA Fellow advertisement just went out, and deadline is May 15th

Committee Reports:

Publications Committee

Proceedings – Carl Libbey

WSWS Newsletter – Carl Libbey

- Newsletter is 4 times a year
- Will reach out to members for more reports/info for the proceedings

Website – Eric Gustafson

- nothing to report

Local Arrangements – Eric Westra

- Nothing to report

Nominations – Pat Clay

- Asked audience to consider serving as board members or elected positions
- Nominating committee met over summer 2023 and identified potential nominees for: President-elect, Research Section Chair, Education and Regulatory Section Chair, and Secretary

Public Relations – Mirella F Ortiz

- Committee have proposed to make an informative WSWS poster that members can print to share at other meetings members
- Social Media Manager reports show growth in all account following, except Facebook, which has been common among societies
- Worked with Sandra to update Operating Procedure for the PR committee.

Fellows and Honorary Members – Rich Zollinger

- Recognized those that nominated members for awards, and encourage other members to do the same

WSWS Representative to WSSA Finance Committee - Rich Zollinger

- Society is financially sound
- Three streams of income that are all having positive returns.

Site Selection – Kyle Roerig

- Working to get back 3 years ahead on site selection
- Have received one quote for the 2026 Annual Meeting - to be reviewed by the BOD
- Also working with the BOD to update the RFP that is sent out to perspective venues to reconsider expectations, or incur more cost due to lack of acceptable concessions in the current environment.

Awards – Harry Quicke (Presented by Tim Prather)

- Awardees were honored at Luncheon for all 6 awards this year, and hoping that we have a full slate of nominees again next year

Poster – Lovreet Shergill

- Thank you of volunteers to set up and tear down poster room
- 83 total posters this year

Necrology – Lesley Beckworth

- Prepared the poster for remembrances for those who had passed that was shared in the Poster session
- Members who passed away during the past year: David Bayer, Keith Carl "KC" Hamilton, Tom Threewitt, Ray William, Stephen Miller, Doug Ryerson, Lauren Thompson

Sustaining Membership – Carl Coburn

- Thank you to Sustaining Members for supporting WSWS
- Were able to secure TeeJet as a Sustaining Member
- Thank you to Dirk Baker for proposing new ideas for a way for smaller companies to become sustaining members
- The BOD approved a new fee structure.
- Ben Westridge will be incoming Chair for Sustaining Membership Committee

Legislative – Ryan Edward (Presented by Alan Helm)

- Committee requested that several items in the Operating Procedures be updated.

Herbicide Resistant Plants – Stephen Valenti

- Committee worked on developing a tri-fold brochure on Herbicide Resistance
- Brochures are at the registration desk, please provide any feedback back to the committee members

Diversity and Inclusion Ad-Hoc Committee – Elizabeth Mosqueda

- Recommended changes to the Operating Procedures
- Also worked with the BOD to suggest edits to the Student Contest Judging form for those where English isn’t their first language

- Will be proposing moving to a Standing Committee
- Thank you to those who have served on the committee

Invasive Species Ad-Hoc Committee – Lisa Jones

- Committee met and discussed possible changes due to Endangered Species Act, and Forest and Rangelands could be impacted but not considered

Needs of our Agency Members (Ad Hoc) – Julie Kraft

- Tim Prather reported that we will be dissolving this committee, and will be addressed by the Public Sector Member at Large on BOD

Student Paper/Poster Judging and Awards– Alix Whitener (Presented by Clint Beiermann)

- Agronomic crops (paper) – Het Desai, MSU (1),Victor Ribeiro, OSU (2)
- Agronomic crops (undergrad paper) – Jamie Burroughs, OSU (1)
- Range, Forestry, Natural Areas (paper) – Lilly Sencenbaugh, MSU (1)
- Horticulture + Teaching, Outreach (paper) – Luisia Baccin, OSU (1), Caroline Toth, NMSU (2)
- Basic Biology, Ecology, Technology (paper) - André Lucas Simões Araujo, CSU (1), Amber Pelon, CSU (2)
- Agronomic crops (poster) – Het Desai, MSU (1), Hayden Lee, NDSU (2), Newman Teye-Doku, UW (3)
- Basic Biology, Ecology, Technology (poster) – Albert Kwarteng, UI (1), Dustin Moreno, CSU (2)
- Horticulture crops (poster) – Tong Zhen, UCD (1), Stephen Chang, UCD (2)
- Range, Forestry, Natural Areas (poster) – Caroline Kittle UW (1)
- Horticulture + Basic Biology, Ecology, Technology (undergrad poster) – Maloree McDonald, USU (1), Maggi Mathews, USU (2)

New Business:

- Vanelle Peterson has been working to identify pictures, and thanked those who assisted in identifying. Will be posted on the website in an updated version.
- Vanelle indicated that there was a proposal to realign the research sections that were under consideration by the BOD, and was approved by the BOD. Changes are captured in the 2023 Summer BOD Meeting Minutes
- We have a member of WSWS Roland Sherman who has been a member since 1964 in attendance who has been a member for close to 60 years that we would like to recognize
- Curtis Rainbolt was honored as outgoing President by incoming President Tim Prather

Call to Adjourn at 8:26 AM by President Prather

WESTERN SOCIETY OF WEED SCIENCE NET WORTH REPORT

April 1, 2023 through March 31, 2024

ASSETS	
Cash and Bank Accounts	
American Heritage Checking	$141,537.71
American Heritage Money Market	$51,071.59
CD#4	$26,398.41
CD#5	$25,408.78
CD#6	$26,518.09
CD#7	$27,135.56
TOTAL Cash and Bank Accounts	$298,070.14
Investments	
RBC Dain Rauscher Account	$160,538.54
RBC Unified	$61,822.47
TOTAL Investments	$222,361.01
TOTAL ASSETS	$520,431.15

WESTERN SOCIETY OF WEED SCIENCE CASH FLOW REPORT

April 1, 2023 through March 31, 2024

INFLOWS ($)	
Annual Meeting Income	131,410.00
California Weeds Book	130.00
Interest Income	632.37
Dividend Income	12,819.13
Membership Dues	1920.00
Miscellaneous Income	3700.00
Royalty for Proceedings - RPR	340.00
Security Value Change	8469.22
Student Travel Account	2005.00
Sustaining Member Dues	18,300.00
TOTAL INFLOWS	**179,725.72**
OUTFLOWS ($)	
Annual Filing Fee	10.00
Annual Meeting Expense	8494.57
Bank Charge	4515.35
CAST Annual Dues	1,500.00
Copies	33.60
Fee Charged	4878.07
Insurance	500.00
Management Fees	30,104.67
Proceedings/Publications	1500.00
Postage	395.37
Summer Meeting	17,366.19
Student Awards	4588.95
Taxes	446.67
Travel to Summer Meeting	599.26
Travel to WSWS Meeting	2458.48
Weed Olympics	1653.60
Social Media	3500.00
Web Site Hosting	4000.00
TOTAL OUTFLOWS	**86,544.78**
OVERALL TOTAL	**$93,180.94**

WSWS 2024 FELLOW AWARDS

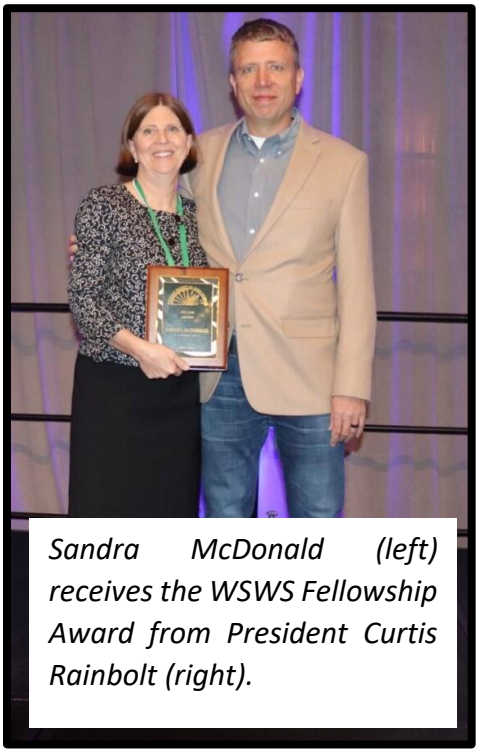
Fellows of the Society are members who have given meritorious service in weed science, and who are elected by two-thirds majority of the Board of Directors.

Sandra McDonald, Mountain West PEST – Fort Collins, Colorado

Sandra was the Environmental and Pesticide Education Specialist at Colorado State University for 13 years where she was involved in specialty crop pesticide research in addition to her role as a pesticide safety educator. She masterfully taught 1,000's of attendees safe and correct application of pesticides. She is an active member of the American Association of Pesticide Safety Educators and the Rocky Mountain Agribusiness. In 2009 she founded Mountain West PEST (Pesticide Education and Safety Training).

Sandra McDonald has been an active member of the Western Society of Weed Science since1998. She has presented multiple papers and posters over the past 25 years and routinely served as a judge for the graduate student poster/paper contest. In 2010, she took over the coordination of the WSWS Invasive Weed Short Course, now renamed the Western Invasive Weed Short Course which utilizes WSWS members as the core training team. She has been a member and chaired many WSWS committees, many of which overlapped. In addition, she organized many WSWS Discussion platforms which shows her capacity to accomplish almost a superhuman workload. In 2020, Sandra served as the WSWS President Elect and holds the dubious distinction of overseeing the first virtual meeting of the society. In 2019 she received the WSWS Presidential Award of Merit from then President Andrew Kniss.

The following is Andrew Kniss's comments about this award: "Sandra helped me figure out my first WSWS discussion session when I chaired the Teaching & Tech Transfer Project in 2010. Sandra proposed the topic to me then Sandra packed extra luggage to bring the audience response systems to Hawaii for that session. Sandra then provided an introductory talk for the session. In fact, as I look through the proceedings to see what I wrote from that session, it seems Sandra even wrote the report for me. As I write this letter, I am realizing that for over a decade I have apparently been taking credit for 'chairing' a Project that Sandra that did all the work."

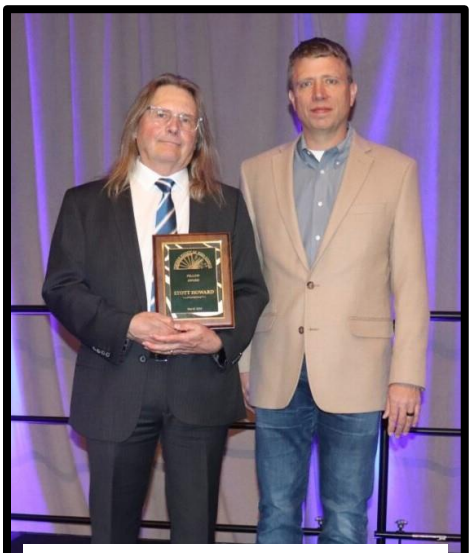


Sandra McDonald (left) receives the WSWS Fellowship Award from President Curtis Rainbolt (right).

Stott Howard, Syngenta Crop Protection, Des Moines, Iowa

Dr. Stott Howard's developing abilities blossomed as a graduate student where he was twice awarded in WSWS student paper/poster contests. He began his Weed Science career at the Washington State University's Northwestern Research and Extension Unit in Mount Vernon as an Extension & Research Weed Scientist. He then moved to industry and received the title of Market Development Representative and then Region Head he moved through the various iterations of ICI Americas/Zeneca Ag Products/ and Syngenta Crop Protection. For most of his career he was not employed in the WSWS geographic region but consistently attended annual meetings and maintained strong connections with students and society members. He served and was chair of many WSWS committees including Awards, Education & Regulatory, Program, and Public Relations. He was an exceptionally strong supporter of students, thrived as a student mentor, has been a student paper/poster contest judge, and has hosted many students on the "Student Night Out" event. He has presented numerous papers and organized and presented in symposia and workshops during the society's annual meetings.

His professionalism and contributions extend to other societies. He served in many capacities in the North Central Weed Science Society, including President, was awarded the Distinguished Achievement Award for Service in 2016, and was given Fellow of that Society in 2022. He also served in various roles in the Weed Science Society of America, the International Weed Science Society, American Society of Agronomy, Iowa Soybean Research Council, and National Cotton Council.



Stott Howard (left) receives the WSWS Fellowship Award from President Curtis Rainbolt (right).

The following are most relevant comments from WSWS society member Marty Schraer, "I believe Stott enjoys developing young scientists much more than developing herbicides. Stott's final role with Syngenta was as the Crop Protection Field Development Heartland Region Head. In that role, Stott guided and developed a number of excellent young scientists. Although Stott took great pride in his people he did always focus on the science. If the science didn't say there was value in pursuing an endeavor, Stott would do his level best to shut it down. He was keen to observe the science and bent on its practical application."

WSWS 2024 HONORARY MEMBER

This award was not conferred in 2024.

WSWS 2024 OUTSTANDING WEED SCIENTIST AWARDS

Outstanding Weed Scientist, Early Career, Public Sector: Albert Adjesiwor

Dr. Albert Adjesiwor, Assistant Professor of Weed Science and Extension Specialist at University of Idaho. To quote from the nomination package "Albert truly personifies the definition of an Outstanding Weed Scientist early career! His research interests in weed science have allowed him to effectively manage a multifaceted weed research program that has advanced our knowledge in weed biology and ecology, cover crop utilization, and management of herbicide resistant weeds".

The Outstanding Weed Scientist, Early Career, Private Sector: Derek Sebastian

Dr. Derek Sebastian, Envu Government Relations Manager. To quote from the nomination package "I have been fortunate to work alongside Derek in various roles through academia and industry and see his contributions in the weed science community. He continually supports university research, landowners, and government agencies to effectively combat invasive plant species".

The Outstanding Weed Scientist, Public Sector: Andrew Kniss

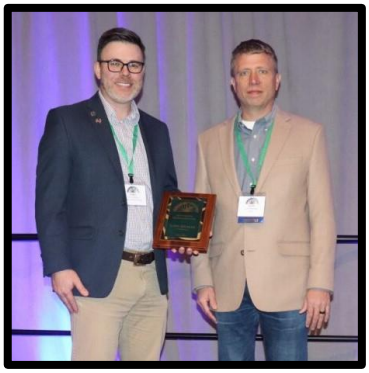
Dr. Andrew Kniss, Professor, Department of Plant Sciences, University of Wyoming. To quote from the nomination package "Andrew's strong research, teaching, and academic leadership is highly impressive across the board. In addition, Andrew's record as a mentor of high quality and highly motivated weed science graduate students is outstanding. I greatly admire the legacy of graduate student training that Andrew is continuing at the University of Wyoming".

The Outstanding Weed Scientist, Private Sector: Greg Dahl

Greg Dahl, Senior Research Manager, Winfield United (recently retired). To quote from the nomination package "Greg has spent his entire career working towards improving weed control for farmers in the Northern Great Plains, nationally, and globally. Greg's role as senior research manager has allowed him to create over 70 crop protection products for growers and retailers across the United States and the world. His work has led to over 10 U.S. and International patents".

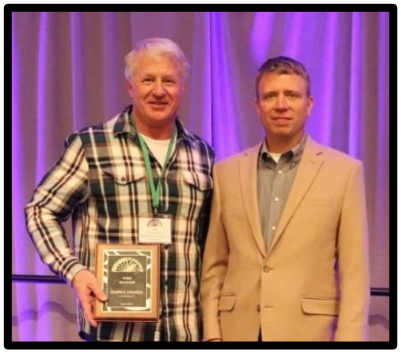
WSWS 2024 PROFESSIONAL STAFF AWARD

The Outstanding Professional Staff: Cody Beckley



Cody Beckley, Researcher, Weed Science Program at Utah State University. To quote from the nomination package “Cody has been involved in the development, establishment, evaluation, and data management for over 150 individual research trials. Cody consistently prioritizes the completion of research projects with high quality and timeliness, displaying a selfless commitment to the program's success rather than personal recognition. Cody's impact as a mentor to both graduate and undergraduate students has been nothing short of exemplary”.

The Outstanding Weed Manager: Joe Swanson

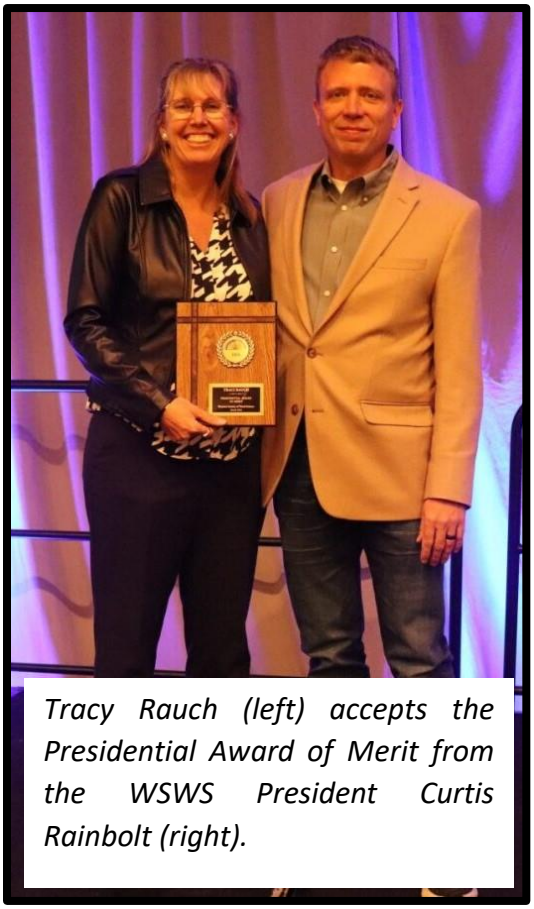


Joe Swanson, Senior Invasive Plant Supervisor, Boulder County Parks and Open Space. To quote from the nomination package “Joe is committed to tackling key issues with an innovative mindset. He takes an active approach in adoption of new tools and technologies to increase both operational efficiency and restoration success. Joe is truly an innovator and trailblazer for restoring invasive annual grass dominated landscapes. One of Joe’s strengths is the successful partnerships he has created with agencies, industry partners, and academia”.

WSWS 2024 PRESIDENTIAL AWARD OF MERIT

Tracy Rauch

Traci Rauch, University of Idaho, received the Presidential Award of Merit from Curtis Rainbolt for outstanding contribution to the society for her many years of service in editing and compiling the Research Progress Reports.



Tracy Rauch (left) accepts the Presidential Award of Merit from the WSWS President Curtis Rainbolt (right).

WSWS 2024 ELENA SANCHEZ MEMORIAL STUDENT SCHOLARSHIP RECIPIENTS

Harry Quicke, Awards Committee Chair announced the recipients of the "WSWS Elena Sanchez Outstanding Student Scholarship Program" were:

Jennifer Valdez Herrera, M.S. candidate, California State University - Fresno

Victor Hugo Vidal Ribeiro, Ph.D. candidate, Oregon State University, Carol Mallory-Smith and Judit Barroso advisors

Tong Zhen, Ph.D. candidate, University of California - Davis

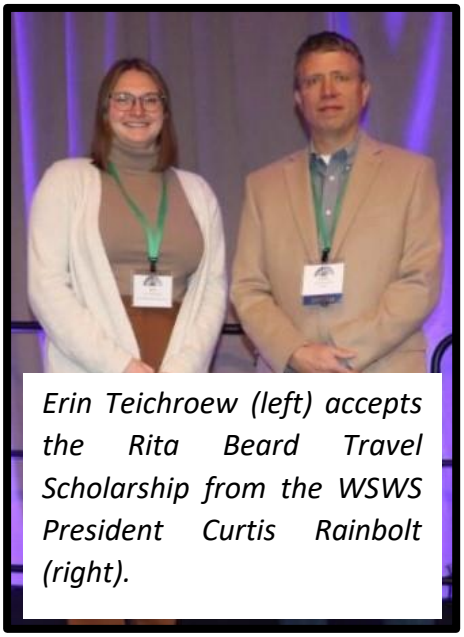
A big thanks to their advisors for bringing along such great promising talent for the future of weed science.

Pictured Left to Right: Tong Zhen, Victor Hugo Vidal Riberiro, Curtis Rainbolt, and Jennifer Valdez Herrera.

WSWS 2024 RITA BEARD ENDOWMENT STUDENT SCHOLARSHIP

The Rita Beard Endowment Foundation Board of Trustees has selected Erin Teichroew (Ph.D. student at Montana State University) for a travel scholarship to attend the Western Society of Weed Science Meeting in 2024. The Rita Beard Endowment Foundation is a 501 (c) (3) non-profit that was created from a generous donation by Rita Beard's family and friends. Funds are awarded to support educational opportunities of students and early career invasive species managers by providing registration and travel to professional meetings including Society for Range Management, Western Society of Weed Science, Western Aquatic Plant Management Society, and the North American Invasive Species Management Association. To read more about the Foundation, learn how to apply for the 2025 scholarships, or make a donation go

Erin Teichroew



Erin Teichroew (left) accepts the Rita Beard Travel Scholarship from the WSWS President Curtis Rainbolt (right).

WSWS 2024 STUDENT PAPER AND POSTER AWARDS

2024 Paper judging committee: Josh Adkins, Clint Beiermann, Alix Whitener, and Georgia Harrison

Twenty-nine student competition judges were recruited and assigned sections to evaluate at the meeting. They were provided with training materials, abstracts, and rubrics. They judged 29 graduate level posters, 6 undergraduate posters, 18 graduate papers, and one undergraduate paper.

Posters: Graduate Level

Weeds of Range, Forestry, & Natural Areas

1st place: Caroline Kittle, University of Wyoming
A Case for EDRR in Wyoming

Weeds of Agronomic Crops

1st place: Het Desai, Montana State University
Effect of relative humidity on glufosinate efficacy in Kochia and common lambsquarters populations.

2nd place: Hayden Lee, North Dakota State University
Tolpyralate and bromoxynil efficacy on green foxtail in small grains.

3rd place: Newman Teye-Doku, University of Wyoming
Evaluation of stale seedbed and delayed planting date for weed management in sugar beet.

Weeds of Horticultural Crops

1st place: Joshua Tong Zhen, UC Davis
Evaluation of electrical weed control in California orchards.

2nd place: Stephen Chang, UC Davis
Evaluating the effect of endothall-treated irrigation water on California crops.

Basic Biology, Ecology, and Technology

1st place: Albert Kwarteng, University of Idaho
Potential impacts of transgenerational memory from weed competition on spring wheat

2nd place: Dustin Moreno, Colorado State University
Basis for dicamba resistance in palmer amaranth (Amaranthus palmeri).

Posters: Undergraduate Level

Weeds of Horticultural Crops, Basic Biology, Ecology, and Technology Combined –

1st place: Maloree McDonald, Utah State University
Seedbank suppression is critical for long-term Dyers Woad Control: It's a long woad.

2nd place: Maggi Mathews, Utah State University
Factors influencing plant response to indaziflan.

Oral presentations: Graduate Level

Weeds of Range, Forestry, & Natural Areas

1st place: Lilly Sencenbaugh, Montana State University
Impacts of herbicide, and macro- and micro- nutrients on non-native annual grass, ventenata, and desired species composition in Montana ragelands.

Weeds of Agronomic Crops

1st place: Het Desai, Montana State University
Herbicide strategies to manage glyphosate-, glufosinate-, and dicamba-resistant Kochia populations in triple-stacked sugarbeet cultivar.

2nd place: Victor Ribeiro, Oregon State University
EPSPS Copy Number Variation is Correlated with Glyphosate Resistance in Some Italian Ryegrass Populations.

Weeds of Horticultural Crops, Teaching and Outreach Combined

1st place: Luisa Baccin, Oregon State University
Crop safety and weed control in organic highbush blueberries using electrical weeding.

2nd place: Caroline Toth, New Mexico State University
Suitability of a barley crop to suppress weeds of chile pepper in southern New Mexico.

Basic Biology, Ecology, and Technology

1st place: André Lucas Simões Araujo, Colorado State University
Investigating dicamba resistance in kochia populations from Colorado.

2nd place: Amber Pelon, Colorado University
GST Inhibition – Influence on Quizalofop p-ethyl Metabolism in Winter Wheat.

WSWS 2024 ANNUAL MEETING NECROLOGY REPORT

At the Thursday business meeting, the WSWS members who passed away this year were honored with a moment of silence. Those members were:

David E. Bayer

David E. Bayer, Emeritus Professor in the UC Davis Department of Plant Biology, passed away on January 20, 2024, in Davis, California. David was born in 1926 in Grass Valley, Oregon. The story goes that the ranch hands didn't get bread the day he was born because he was being warmed in the oven instead of the bread. He is survived by Sharla, his loving wife of more than 58 years; daughter Darla Rosenthal; grandson Jacob; and numerous nieces, nephews and other dear family members.

Being from a small town, he went to elementary school in town and then took the bus to Moro, Oregon, for high school. After working a winter digging postholes in the frozen ground of northeastern Oregon, he decided college was a better option and enrolled himself and his younger brother that spring.

He received his bachelor's and master's degrees at Oregon State University and his doctorate from the University of Wisconsin. In 1962, he moved to Davis to take a job as a new professor, meeting his soon-to-be wife thanks to some friends shortly thereafter. Dave taught for more than 50 years at UC Davis in the botany department. He traveled all over the world teaching and advising on his specialties in weeds and rice.

When he wasn't teaching and running experiments in the greenhouses on campus, he coached his daughter's soccer teams and refereed soccer as well. When his grandson was born, he was the happiest Poppa around. When Jacob started playing soccer, Poppa D was on the sidelines by the goalkeeper's box at every game he could attend. His grandson was the goalkeeper. He also attended his grandson's baseball games and watched him show lambs for a few years in 4-H.

In his lifetime, he rode his horse to school and ended his career at UC Davis sending emails on his computer. He saw so many changes and advances in the world during his life. He loved seeing all the things you could do with a cell phone. Learning and education were so important to him. He also loved a good joke and shenanigans with his friends and family. The twinkle in his eye let you know he was up to no good and there would surely be a laugh to follow.

Dr. Bayer was a pillar of weed science and weed control research in California for nearly 30 years. He started his career as a University of California weed extension specialist in 1958 and, in 1962, accepted a position as a Professor in the UC Davis Department of Botany which later became part of the Department of Plant Biology. Dr. Bayer retired from UC Davis in the mid-1990s and remained active as an emeritus faculty member for many years, continuing some of his research on herbicide-resistant ryegrass among other projects. He was particularly known around the world for his work on weed management in rice systems; the California growers held him in the highest regard and presented him with the California Rice Industry Award in 1994. Among many awards for research and teaching, Dr. Bayer was named as Fellow of both the Western Society of Weed Science (1978) and the Weed Science Society of America (1988).

Keith (KC) Carl Hamilton

K.C. Hamilton passed away on March 26, 2023, after a brief illness. He was 94 years old. He is survived by his loving wife Pat of 70 years, 3 sons (Bill/Sylvia, Kim, Patrick/Monica), 8 grandchildren and 6 great-grandchildren. He was preceded in death by his parents and sister. Pat and Keith spent many weekends in the White Mountains; he was an avid outdoorsman and an expert hunter/fisherman. Keith taught for 36 years at the University of Arizona in the College of Agriculture. He loved the Santa Catalina mountains and hiked nearly every trail with his wife and sons. He also adored squirrels, so whenever you see a squirrel, think of Keith.

K.C. served as Secretary of WSWS in 1967, and President-elect and President of WSWS in 1968 and 1969. He was awarded as a Western Society of Weed Science Fellow in 1973.

"Mixed with research, teaching, and extension were writing reports, presenting papers, endless committee meetings, and serving various offices in the Western Society of Weed Science and Weed Science Society of America. Two of my best memories are from 1973 and 1979 when I became a Fellow in those societies. I remember because of my respect for the other weed scientists who were so named." – K.C. Hamilton, Fellow, 1973 (The Western Society of Weed Science 1938 – 2021. Peterson, V., Banks, P., Lym, R., Morishita, D. (Eds.))

Doug Ryerson

Doug Ryerson passed away March 6, 2022. Doug grew up in Bozeman, Montana where he earned his B.S. in Agriculture Science from Montana State University. Doug went on to earn his M.S. and PhD. in crop physiology from the University of Wisconsin, Madison.

Doug began his career as an area crop specialist for the University of Idaho before going to work as a Product Development Specialist for Monsanto. He has a long history with Monsanto, where he made a concerted effort to improve crop production through better weed control, specifically in cereals.

Throughout his career he actively served the WSWS in many capacities including Past President, President, President-elect, Secretary, and moderator for the Agronomic Crops Section. He also participated in the student educational enhancement program. Doug will be remembered for his participation at WSWS but mostly as a husband, father, and a friend with a kind heart.

Stephen D. Miller

Stephen Douglas Miller,77, passed away December 21, 2023, in Cheyenne, WY at the Davis Hospice Center. He was born March 27, 1946, in Greeley, CO.Steve is survived by his wife, Bonnie; sons, Jason (Jamie) Wichita, KS, Eric (Stacy) Cheyenne, WY; sister, Dianne Brown, Johnstown, CO; grandchildren, McKinley, Addyson, and Henry; and numerous nieces and nephews. Steve was preceded in death by his parents, Dorothy Jane Miller and Niles Stephen Miller, and brother-in-law, Gregory Brown.

Steve grew up in Platteville, CO, spending time on the family dairy farm. He shared many stories of playing with his cousins and working with his grandpa, uncle, and dad. Steve decided early on that milking cows was not for him. Steve graduated from Valley High School, Platteville, CO (1964). He obtained his BS (1968) from Colorado State University, Fort Collins, CO. Steve

attended North Dakota State University, Fargo, ND, earning his MS (1970) and PhD (1973). For 12 years, Steve enjoyed a faculty appointment at NDSU.

In 1984, Steve joined the faculty at the University of Wyoming in Laramie. He was academic advisor to 65 graduate students (39 earning their MS and 26 their PhD). He was dedicated to the research of weed control in crops at the UW Research Stations. Steve published more than 70 research articles in peer-reviewed journals. He was a member of the Western Society of Weed Science (President 1993), the North Central Weed Science Society (President 2006), and the Weed Science Society of America. Steve worked closely with the Wyoming Weed & Pest Council. He was well known and respected among fellow scientists and crop producers across the western states. In 2005, he was appointed Associate Dean, College of Agriculture, and Director of UW Research Stations. Steve retired in 2010, after 26 years with UW. To some, Steve was more than a professor or mentor. He was a larger-than-life man in suspenders. He wasn't afraid to get dirty, and loved to be out in the fields, working alongside his students. Steve never had trouble being heard, his booming voice was unmistakable.

During his career, Steve was honored to receive many awards for his dedication to research and teaching. Most noteworthy: UW, George Duke Humphrey Distinguished Faculty Award (1993); UW College of Agriculture and Natural Resources, Vanvig Distinguished Lifetime Achievement Award (2012); NDSU College of Agriculture, Distinguished Alumni Award (2007); and CSU Department of Soil and Crop Sciences, Honored Alumni Award (2019). When accepting the Vanvig award, Steve was quoted as saying, "There's got to be a better way of controlling weeds than a hoe. That seed was planted in me early since I was helping weed the beet fields when I was little. That's why I went into agronomy."

Steve and Bonnie were married in 1969. They loved playing bridge with Dorothy and Niles at the family cabin in Colorado. Steve enjoyed playing cards and games with family and friends. He enjoyed watching the boys' sports teams and going to the park. He followed football, basketball, hockey, and golf. He loved being with his grandchildren, going to auctions with Bonnie, spoiling his beloved cats, and tending to the yard and flower beds. Steve was an avid collector of vintage cast iron farm toys.

A memorial fund was created to assist graduate student travel to WSWS. Donations can be made through wsweedscience.org.

Lauren Thompson

Lauren Gail Thompson, 28, of Las Cruces, New Mexico passed away Saturday July 8, 2023, at Methodist Hospital in San Antonio, TX after a lifelong battle with pulmonary arterial hypertension (PAH). Always courageous and optimistic, she never let the disease define her life. She was a member of WSWS for 10 years and worked for Marathon-Agricultural & Environmental Consulting serving as the Assistant Business Manager to Phil Banks. She was instrumental in the success of every WSWS meeting during her employment with Phil, handling registrations and membership data.

Lauren was born on January 8, 1995, in Las Cruces, NM. She was diagnosed with PAH in 2002 at the age of 7. Pulmonary Hypertension is an extremely rare disease, is difficult to diagnose and

manage, and the drugs used to treat it can leave the patient with many days of discomfort and inability to function "normally". Perhaps worst of all is the fact that it is not a visible disease, and is therefore misunderstood by friends, family, and coworkers. Lauren had her share of "PH" days, but always did her best to stay cheerful and carry on. She graduated from Las Cruces High School in 2013, and attended New Mexico State University, where she was proud to attain her Associate of Arts degree in 2021.

Lauren recently found her passion for painting and created many beautiful canvases for her friends and family. She was happiest with her closest friends and family and adored her young niece and nephew. Anyone who knew Lauren was touched by her sweet, compassionate, cheerful personality and love for all whose lives she shared. Her family and friends will miss her more than words can ever describe.

Lauren is survived by her parents David and Carla, her brother Kevin, his wife Lauren (yes, THAT was confusing!), nephew Luke, and niece Emily. She is also survived by her grandparents Charles and Carol Thompson as well as many aunts, uncles, and cousins who loved her dearly. She is predeceased by her grandparents Carol Condie and Kent Stout.

Those who would like to honor Lauren are encouraged to learn more about PH and donate to the Pulmonary Hypertension Association at phassociation.org.

Thomas B. Threewitt

Thomas (Tom) Buntin Threewitt, Sr., 79, of Garnett, Kansas, passed away peacefully with family by his side on Monday, May 15, 2023. He was born in West Frankfort, Illinois on April 5, 1944, to William Edward and Loa (Buntin) Threewitt where he grew up on a crop and livestock farm in Aiken, Illinois and developed a love for agriculture.

In 1961, Tom married his high school sweetheart, Nancy and his career took them to Larned, KS where they raised their four children, Tommy, Susan, John and Becca, on their farm. He took extreme pride in his five grandsons, Trey, Seth, Gabe, Zeke and Izzy, spoiling them and rarely missing a sporting event.

Tom's 'grandson responsibilities' on the farm were many. Tractor rides, keeping the pool clean (especially for Fourth of July festivities), watching SpongeBob and learning how to walk around legos just to name a few. As a matter of fact, in order to visit his grandkids more often, he would set up work field plots close to where the grandsons lived. He would hide the grandson's Christmas present purchases from Nancy to ensure everyone was surprised, but that usually meant duplicate presents under the tree. After the move to Garnett and the grandsons got older, Stumpy the squirrel, who lived in Tom & Nancy's front yard, became one of his new responsibilities. Stumpy ran all over their yard every day, so Tom kept his eye on his new tail-less friend.

He received his Bachelor of Science in Plant Science (1966) and Master of Science in Weed Control (1968) from Southern Illinois University and his Ph.D. in Weed Science from University of Illinois in 1972.

Tom began his career as a field research representative in Kansas for the newly merged company of Ciba-Geigy, staying through several mergers and name changes, retiring from Syngenta after

32 years. He then established his own consulting and contract research company, PACA Ag, LLC. Where does the name PACA come from? His 2nd oldest grandson, Seth, struggled to say "Papa" and it always came out as "Paca" and the other grandsons adopted the same name for him.

Tom was involved with the development of the Kansas CCA program, serving on the board for 6 years with one year as the President. He was a member of many other industry organizations including Kansas Agricultural Retailers Association, North Central Weed Science Society, Western Society of Weed Science, Weed Science Society of America and Council for Agricultural Science and Technology. Tom's expertise and work ethics earned him an invaluable reputation with his peers in both industry and academia.

Tom is survived by his wife Nancy; his four children Thomas B. Threewitt Jr., K. Susan (Justin) Macy, John Threewitt, and Becca Brown; five grandsons Thomas "Trey" B. Threewitt III, Seth W. Threewitt, Gabriel Brown, Ezekiel Brown, and Israel Brown; his sister Patsy (Carroll) Bolen; sisters-in-law Paula (Steven) Arthur, and Clara (Greg) McClean; and many nieces and nephews.

In lieu of flowers and plants, the family requests memorial contributions to the Anderson County FFA chapter through a GoFundMe Account (Thomas B. Threewitt, Sr. Obituary - AC KS FFA).

Raymond D. William

Ray William of Roseville, CA died on Sunday, July 23, 2023, following a series of strokes. Ray was born to Ray and Betty William on October 1, 1946, in Denver, Colorado. With his family, he moved to Washington state in 1955.

He worked at the WSU Puyallup Research and Extension Center beginning in high school and earned B.S. degree in Horticulture at Washington State University in 1968, followed by a MS in 1972. After 2 years of research in Brazil, he received a Ph.D. in Horticulture from Purdue University in 1974.

His initial professional position was at The Asian Vegetable Research and Development Center (AVRDC) near Tainan, Taiwan. He and his wife Nancy lived at the center for 2 ½ years. He then served on the faculty at the University of Florida for 3 years. Ray then joined the faculty at Oregon State University in January 1980 as a Cooperative Extension Specialist in the Department of Horticulture, retiring in 2008. He also served in Malawi Bvumbwe Agricultural Research Station (BARS) from 1986-1988.

Ray was an active member of WSWS, WSSA, ASHS and the Oregon Society of Weed Science. He devoted his early career to popularizing ‘living mulches’ in western Oregon. He provided extensive service to the Department of Horticulture and Oregon State University and was coeditor of the PNW Weed Management Handbook for more than 2 decades. He created the Raymond D. William Teaching Innovation Fund at WSU Vancouver. Memorial contributions can be made to student scholarships in the Horticulture Departments at WSU or OSU, or to First United Methodist Church, Roseville.

WSWS 2024 ANNUAL MEETING RETIREES REPORT

Since the last meeting, a total of two members of the society have retired from their work positions and from the Western Society of Weed Science. The members were formally recognized at the Business Meeting and during the member and retirees' reception. Their society meeting attendance, years of service, and professional leadership will be greatly missed.

Dr. Dennis Scott, FMC Corporation. Dennis retired from FMC in February 2024. Dr. Scott received his Ph.D. at Oklahoma State University in 1990 then spent 4 years at Purdue University. In 1994 he became a Product Development Manager for FMC Chemical Company for 8 years, then was a Product Development Manager for Bayer Crop Science for 12 years. He then went back to FMC and served in the same position until his retirement on February 5, 2024. His first WSWS meeting was in 1995 and was a member of WSWS for much of the 30-year span. He participated in Student Paper and Poster judging several times, including serving on the committee.

Dr. Terry Mize, FMC Corporation.

Thanks to Alix Whitner, Scott Cook, and Rich Zollinger for the information.

Submitted by: Joel Felix, Immediate Past President

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