Participant Introductions

1. Kelly Bennett: working on coordinated resistance database in Canada with consistent, unbiased messages
2. Joe Yenish: varying soil conditions
3. Roger Gast: herbicide discovery, using only S kochia
4. Joan Campbell: high reliance on RR corn and soybean for dairy industry
5. Jeff Hopp: education for timing methods and multiple sites of action, kochia is high concern
6. Gabrielle, Univ of Neb post-doc with Greg Kruger, looking to learn about kochia
7. Nevin Lawrence: kochia is #1 weed in western Nebraska, lots of integrated management work
8. Steve Elliott: Western IPM Center communications
9. Caio Brunharo: looking to get involved, single and ready to mingle
10. George Frisvold: economic and social barriers to adopting R mgmt practices; short term vs long term decision making; also group thinking
11. Cody Creech: herbicides in fallow, trying to get ahead of kochia
12. Albert Adjesiwor: post-doc at U of Wyo, integrated mgmt
13. Andrew ‘tweet it’ Kniss: range of herbicide management, specific R management, seedbank ecology, thermal and moisture requirements for germination, cover crops, stale seed banks,
15. Natalie Aquilina, visiting scholar at K-State
16. Charlie Hicks: can have good new kochia products, but hard to make it affordable for dryland
17. Bob Bruss: looking for older herbicides that can have new fits; diclorprop-P in 2,4-D resistant crops on weeds resistant to 2,4-D and/or dicamba
18. Graham Collier: kochia is driver weed in cereals and pulses in Canada, products with multiple modes of action
19. Vipan Kumar: glyphosate resistance, lots of work on Palmer amaranth as well
20. Terry Mize: has worked on a range of products in multiple crops for kochia; kochia is a target in herbicide discovery pipeline
21. Len Juras: pre-mix multiple mode of action products, commercial concepts; thinking about seed banks, late season treatments to reduce seed viability
22. Mark Oostlander: leads herbicide development team in Canada for BASF, kochia in pulse crops; pre and post harvest to manage seed bank (saflufenacil?)
23. Charles Geddes: crop rotation, integrated cultural management, biology of seed set for viable seed production, kochia regrowth following harvest
24. Brad Erker: looking to learn and participate
25. Phil Westra: range of kochia research activities
26. Tyler Benninghoven: CO Wheat seeds and trait specialist, how to bring effective products to market
27. Brian Jenks: kochia problem throughout ND, multiple crops, fluroxypyr resistance big issue; glyphosate resistance widespread; control early emerging kochia in spring with Valor;
28. Ryan Hunt: looking at how to make several products work better
29. Cris Willenborg: U Sask, 5-10 yr of work on kochia, residual products in fall or spring with cultural management; products to limit viability of seeds produced, looking at seed predators
30. Rob Gulden: U Manitoba, some work on kochia, but kochia isn’t a major problem in his part of the province; kochia surveys, resistance; effective kochia control
31. Kevin Dorn: disease resistance improvement in sugar beet
32. Nithya Subramanian: molecular markers and genomics in plant breeding; molecular weed science at TX A&M; develop cultivars with HR traits; HR survey conducted by Muthu with Vipan and Misha; wheat/fallow, grain sorghum, cotton
33. Sushi, post-doc at K-State with Mithila; mechanisms of resistance
34. Eric Patterson: genomics, gene duplication
35. Sarah Morran: molecular biology probably
36. Olivia Todd: fluroxypyr resistant kochia mechanism, resistance assays
37. Eric Westra: kochia HR surveys, kochia in canola, and sugar beet
38. Debalin Sarangi: new at U of Wyo, Powell, kochia is major issue; many little hammers with big hammers, new projects
39. Prashant Jha: recently moved to IA State, now focused on waterhemp; 9 yr of kochia research at MT State; integrated management especially in irrigated crops; major issue in wheat fallow, fall residual herbicides cause big differences, more wheat-pulse rotations; drone based hyperspectral imaging to map kochia in different crops; spectral signatures for HR kochia; recent major review article on HR kochia
40. Todd Gaines - CSU, genomics, molecular biology, digital agriculture, integrated management
Grower and Crop Consultant Panel Q&A:

Marvin Bay: Corn, Sugarbeet and occasional hay
Champion kochia grower!
Had kochia problem after nortron in SB, followed by alfalfa (Good forage cuttings)

Kent Davis (Crop Quest):
Full agronomic service without incentives (product etc)

Alan Linnebur: Wheat-corn-corn (typical rotations)
Adams and Arapahoe country grower
Worked in extension at the university of wisconsin
Need for practical research that growers can use (Add credibility to academia)
Manage water first and weeds 2nd (Water to bu!) (no-till importance)
Proactive approach to weed management ( willing to

Dave Reichert: Western Sugar
Worked for UNL
Dependence on either glyphosate or tillage

What information delivery is most impactful for your areas?

Marvin: Farmers can be skeptical at new practices, more likely to adapt if they can see
the improvement first hand. Progressive farmers can impact others to adopt. Read about and
talked to friends out east about strip tillage before adoption (wanted to make sure it worked
before trying).
Dave: Have focused small group meetings on specifics with cost analysis (two key
things growers want to hear)

Kent: Find the “early adopters” to target and work with to influence other growers.

What would it take for growers to adopt cultural practices?

Alan: Ran on farm yield comparisons to determine optimal wheat row spacing.
Overall cost of cultural practices will be the biggest impact to adoption.
Cost of a single tillage event (short and long term cost vs benefits)

Do we need to have regional demonstration sites for new technologies/best practices?
Demonstrate area-based coordinated kochia management, case studies?
Prioritize new practices that have lower input cost - cultural, agronomic, etc.
Need a metric to prioritize investments and management practices
Plant breeding for weed suppressive/competitive crop: if it pays off, farmers would adopt, could be useful

Growers want to hear specific information, first-hand, that they can apply to their operation
Summarized well, how it applies

Group A Scribe: Olivia Todd
Group B Scribe: Sarah Morran
Group C Scribe: Eric Westra
Group D Scribe: Eric Patterson

Group A - Olivia Todd, Scribe

Biology and Ecology

Biology and competition studies - extrapolating to real world conditions, crop competition but not all spots in the field are the same. - that becomes a seed reservoir.

Experiments on the “low spots” or how those are affecting seed production. Mapping, spectral imaging (crop vs non-crop and how does that change kochia biology).

Kochia competition in fallow, can you mow vs plow for conservation. Spot tilling, what does that do. - shifting to paraquat and sweep

How does kochia grow in saline conditions? Drought, acidic, etc.

Are the herbicide applications effective and properly labeled for each environment?

Spectral imaging for kochia resistance?

Overreliance to herbicides, leaves viable seed.

Regrowth - viable seed, what does this look like

Shifting the seed production window - cutting and applying a post harvest to delay the regrowth.

Kochia for silage in winter wheat
Kochia is genetically diverse so it was hard to plant out as a crop, but there could be forage value

- Blister beetles
- Pathogens, etc.

Seed predation on kochia, and would cover cropping help.

Does OM content affect kochia seed viability

What is special about the remaining seed that is viable in the field?

How do you unravel this question?

Lambsquarters vs kochia and the similarities between them - why does one survive x herbicide

**Integrated Management**

**Discussion Q’s**

1. What are some new tools for kochia control? - NOT talking about resistance diagnostics.
2. What do growers need the most help with in terms of kochia control?

   - Breaking habits, providing convincing evidence to change their practices.
     - Most growers underapply
   - Cover crops to affect kochia germination in the fall that the primary crop could outcompete?
   - Lack of understanding of the density/problem level in their field.
   - Can you put a cost on the area that the grower is losing
   - Planting out allelopathic species?
     - How do different allelopathic compounds affect different crops/kochia?

3. What field metrics should go into a kochia management tool?

   - Topography
   - Soil testing data
   - Crop you're choosing to plant and how that will shift your mgmt plan
   - Field use history
   - Mapping at harvest and before harvesting to see the efficacy of your management plan
   - Multi-year management
   - Managing the crop rotations
   - Row spacing/spatial arrangement, recommendation
   - Economic benefit
   - Planting window based on location/region (varies across north america)
- Row directionality?
- Moisture
- OM content
- Other species for consideration

4. Integration of machine learning, etc. Would green activated tillage in fallow be useful?
   - Adaptation may be accepted only if there is a short term solution.
   - 10% return consistently is the threshold for people for adaptation.
   - Economic drivers
   - Targeting the new generation of farmers for this technology
   - Limited time to micromanage the details on a large farm

5. What would be a practical tool to reduce seed set?

6. Cultural, chemical and seed management are the top 3 suggested research areas proposed by the survey. What are some areas in cultural management that can be potential targets for research?
   - All of the machine learning systems (fire, laser, till, spot spray)

7. How do we use the cropping system to manipulate kochia seed production?

Ideas/priority topics that nevin got back from survey-
How does environmental spatial variability impact kochia fecundity and longevity
Impact of pre-
Targeted crop rotations
Cover crops and silage crops

**Herbicide Resistance**

Todd’s lab is making a marker database for KASP that contains all the known SNPs for ALS, ACCase, Gly, etc. resistance mutations.

Certain types of resistance could make it difficult to design a test.

In-field diagnostics exist for blackgrass, BReD works by detecting the glutathione transferase AmGSTF1—a protein that is found in high concentrations in black-grass populations that have evolved resistance to multiple classes of herbicides. (pregnancy style test)
1. Which herbicides should be considered a priority to develop resistance diagnostics for?
   a. Auxins, different chemical classes
   b. Glyphosate
   c. ALS
   d. ACCase

2. Which herbicides should we prioritize in-field resistance diagnostics
   a. 

3. How can molecular diagnostic tools be integrated into a management plan
   a. Diagnostics in different conditions may give rise to false positives.
   b. High adaptation for this technology
   c. 

4. How can we develop these diagnostics?
   - Get money, try things.

5. How can we use field survey data to inform resistance management tools?
   i. A line resistant to different herbicides, and would be useful in the private sector as well.
   ii. Useful for new product testing
      - Allows you to think ahead in terms of management

6. Should we upkeep kochia seed lots with different phenotypes for researchers?
   a. Maintaining seed populations is important for long term. How can we do this?
   b. Kevin Dorn

Repository of standardized protocols for resistance diagnostics
   - Freely licensed

Getting people to scout their fields
   - Timing

Correlation between resistance trait vs. phenotype

Education and Social Science

1. After hearing these presentations, how effective do you think our current resources are for kochia management?
2. What is the biggest challenge in getting a grower to adopt researched based management practices, and how can we overcome this (money probably).
3. Why do farmers follow or not follow the advice given to them?

4. What are some important things to include in kochia resistance management resources?
   a. Integrated weed management doesn’t cost you a lot of money, so an economic study that shows a profit gain if that’s true. Profitable in the short term?
   b. 

5. What are your opinions on community efforts to tackle an herbicide resistance issue?
   a. Calling on farm leaders
   b. Getting someone to try it and see that it works in the community
   c. Identify the early adopters and sell it as a grower idea to increase its appeal
   d. “Let it adopt itself” because if it works, it will

6. How should we compile these resources so that they are accessible and identified as trusted?
   a. One site that is trusted and acts as a repository for trusted sources

7. Regional kochia guide that covers different scenarios
   a. Zoning guide based on first/last frost dates and when you might see germination/kochia lifecycle & then recommendation guidelines.

Recipes for success:

Showing the direct results of reducing seeds etc. if you follow these practices (quantitative, empirical data)

Specific examples and making it more clear which herbicides and trade names are in each chemical class.

High importance of learning the modes of action

Extension and researchers are on the bottom of the trust list.
- Is this something we should try to change?
- Are extension agents properly trained in the public eye to handle agronomic problems?

Discussion Notes, Western IPM Center Kochia Work Group, 2019
Biology and Ecology

Vipan - research gaps, impact of cultural practices, cover crops/IPM, tillage, strategic tillage

Charlie hicks - what is the effect of tillage on the seed bank what is the long term effect of this on soil

Vipan has grant to look at tillage

Control reduces movement

Caio - need to understand how the weeds decline over time in the seed bank, need to understand the more viable seed bank - we are selecting for it

Vipin alternate crops particularly in fallow fields

Caio - is cover crop a viable option, vipin maybe

Caio, increase organic matter, interaction with seedbank, microbe interactions

Vipin, cover crops interaction with seed bank, residuals interaction, optimization of application

Todd: question of how much is kochia seed moving around and contributing to herbicide resistance - farmers blaming their near neighbour

Tumbling aspect of kochia,

Collier: need to have more information about the evolution of resistance so can see if it is multiple evolution - think it is evolving in field and staying within the field no longer long distance movement

Todd - how much is coming in from outside?

Charlie: probably the same as it has ever been

Collier: the numbers of resistant populations are much higher now

Phil: do we know how far the seed will go - only the study by hugh beckie, but what are the factors, some research has been done with tracking collars

No information on the macro movement within the field

Vipin: what is the pollen flow between kochia?

Phil: pollen can have persistence for up to 12 days

Seed persistence - only takes the 1-2%

Robert bruss: for the outskirts of kochia range can tree breaks, confine it somehow?

Vipin: any research into underground

Important abiotic stress traits:

kochia , cold tolerance,

Collier: interesting biotype comparisons across the kochia range, regrowth vigor

Charlie: joint project - weed scientist and industry

Pangenome important for population genetics
Phil: areas of fundamental biology, is there room in the cult for people from other research areas to be involved, bringing expertise.
Robert bruss, cold tolerance but also heat tolerance, interaction of high temperature and herbicide efficacy, will the range of kochia change as environment heats up

Ryan hunt: long germination range, are the later germinating plants changing in traits, harder to control, herbicide avoidance, people think pres aren't working as well but really the plants are just coming up later

Phil, we need to come up with a few priorities for
Why isn't kochia as big a problem in europe
Todd, they have it but it isn't such a big problem

Synergizing Crop competition and pre's, at what seeding rate are we reducing seed, at what stage are the plants setting see
Interaction of cropping system and kochia, we have a very diverse range of cropping systems how does that effect kochia, which side of the border is it more of a problem because tools change

**Integrated Management**
Discussion Q's

8. What are some new tools for kochia control? - NOT talking about resistance diagnostics.

   Terry: enlist, chemical control? 2,4d isn't the best on kochia, ppos the same with post harvest but then problems with plant back
   Robert: now that we have enlist cotton, herbicide R w application
   Charlie, hppds are last mode of action for in crop
   Vipin: cover crops, tillage , alternate crops eg forage, pre-programs particularly where gly isn't working
   Charlie: chemical control, post harvest paraquat just after harvest
   Challenge with pre- with kochia is the activation moisture and economics
   Education to spread work load, what type of field conditions are best for using fall application not just one strategy for all, different weed density etc change the application technique
   Not just the cheapest but strategy to spread the workload across the season

9. What do growers need the most help with in terms of kochia control?
Terry: if you asked a grower, give me something to replace glyphosate, cheap and easy
Vipin: things get complicated when try to start proposing complicated IMP strategy
Farmers are working year to year, particularly because of the economy
Terry: the scope of agriculture for IPM is proportional to the uptake of a technology, the most successful IPM is usually in smaller systems, easier to manage and higher value

Subsidies
Growers need to know the resistance profile of their populations to motivate them to adopt IPM strategies
Terry: is there a quick and easy way to develop diagnostic test
Charlie: field diagnostics were being developed
Collier: we have testing, one problem is if a grower gets a negative test for one population they then think they don't have resistance
Natalie: a positive of testing would be to help develop the management tool
Robert: if the farmer gets a positive can help change
Todd: field diagnostics, still doing it in BAYER, send out instructions, generally it is ryegrass getting sent in, there is one in-field test in the UK, but most populations are already multiple R

If we had an in-field assay, need to be able to identify the biotypes in the field
Todd; is there value to having an in-field assay for growers to real-time identify r in their field
Natalie: if they could do it in the field with a consultant would be better
If have this information can make better management timing,

Field metrics, variables like animals

10. What field metrics should go into a kochia management tool?
Vipin: lots of biology/ecology (seed biology/seed production) but need to put into model, need soil moisture, seed density, multi-use
Charlie: have great tools for IPM but all have trade-offs, tillage and cover crops sacrifice moisture
Big job to collate all the information
Robert bruss: weed harvester etc, may be value in these technology

Collier: just launched weed-it, optical weed spraying precision in the field, use general chemistry over whole field but then come back in with more expensive chemistries with targeted application
Robert bruss: we usually fund projects looking at sites that have high density of weeds but dont really look at low-density situations which may come up more in real life

Vipin: crop competition, need to always put the crop rotation in the light of economics, is it viable for some approaches to work

Collier: pulse growing areas have site specific approaches, complete non-use of the field

Terry mize: would there be a possibility of the USDA to pay farmers to not grow a crop to deal with resistance? Cover crop
11. Integration of machine learning, etc. Would green activated tillage in fallow be useful?

12. What would be a practical tool to reduce seed set?

13. Cultural, chemical and seed management are the top 3 suggested research areas proposed by the survey. What are some areas in cultural management that can be potential targets for research?

14. How do we use the cropping system to manipulate kochia seed production?

Collier: drones and isolating escapes, finding and returning to escapes
Charlie: BAYER has the whole field monitoring systems

Irrigated will lead but fallow system have no value so need strategies to increase the value of this rotation time

Ideas/priority topics that nevin got back from survey-
How does environmental spatial variability impact kochia fecundity and longevity
Impact of pre-
Targeted crop rotations
Cover crops and silage crops

Herbicide Resistance

“Resistance diagnostics” doesn’t meant IN FIELD diagnostics. We’re talking molecular markers, ppl.

Todd’s lab is making a marker database for KASP that contains all the known SNPs for ALS, ACCase, Gly, etc. resistance mutations.

Certain types of resistance could make it difficult to design a test.
In-field diagnostics exist for blackgrass, BReD works by detecting the glutathione transferase AmGSTF1—a protein that is found in high concentrations in black-grass populations that have evolved resistance to multiple classes of herbicides. (pregnancy style test)

Robert: did we start our kochia study already behind the ball, is 2,4D the actual fist R developed, how does this relate to auxin cross resistance, is kochia R to 2,4D or is there a natural tolerance
Kent davis: what is control, is the same for everybody, what used to be control isn’t control now, used to be suppressing weed to give crop an advantage but now farmers expect a kill so can avoid cultivation, need to think not just crop yield, now thinking about use of natural resources, soil health
Todd: does that extend to r testing, would it be more useful for us to have a common definition of what resistance is for each herbicide/species, one person’s R is another person not resistance
Quick test fit in here, diagnostic tools, leaves in a solution overnight to see if something is r
Caio - what would we test, already testing auxins but should we be monitoring for developing r to new chemistries to get early detection
Kent davis: fluoxy could be used on healthy to control kochia, in small grains the K survivors would stay small until the canopy would die back then would re-initiate growth, farmers are fighting - dont want weeds but have all these extra pressures like land stewardship to consider when managing weed populations

7. Which herbicides should be considered a priority to develop resistance diagnostics for?
Glyphosate as #1
What herbicides are going to potentially to carry over, resistance testing can help change future management strategies
Auxins - need more work, specific to the chemistries, pyrosulfitol
Shifting germination timelines
Ppos need to be identify soil vs foliar
Kent: discussion question: resistance is post emergence but not pre. Is that common for other herbicides,
Collier: yes for the group 14 herbicides
Can we have short triazines with short residual, but they also enhance soil breakdown/microbial breakdown
Dryland systems need to preserve their residual
Robert bruss: the auxins, would you screen them separately or would you do a panel screen, several auxins

Kent davis: would adoption of a diagnostic be restrictive if it becomes too complicated
Farmers are happy to use the send in diagnostics
Not likely to do a pre-screen, but after more likely for escapes
Caio: would farmers use a diagnostic tool on site?
Kent: probs not. Farmers are busy

8. Which herbicides should we prioritize in-field resistance diagnostics
9. How can molecular diagnostic tools be integrated into a management plan
   Caio: would farmers use a diagnostic tool on site?
   Kent: probs not. Farmers are busy
   Collier: diagnostics would allow to benchmark from year to year
   Sushila: if they have a quick test can treat escape before application window is closed

   Maybe a university diagnostic program to send in samples would help, jump start research into particular resistance

   Caio: rice commission funds the weed sci group to do the diagnostics
   In texas USDA provides funding for noxious weeds so maybe there are more funding sources available, need to jump start involvement
   Charlie: would growers pay
   Kent: someone else
   Collier: how they are set up, nufarm pays cost because they are testing failures

   Collier: glufosinate or paraquats for diagnostics
   Caio: use other spp to use markers to track resistance
   Kent davis: we know we have r kochia also have mustards and brome other spp to control
   Research into combination

10. How can we develop these diagnostics?
11. How can we use field survey data to inform resistance management tools?
12. Should we upkeep kochia seed lots with different phenotypes for researchers?

Education and Social Science

8. How effective do you think our current resources are for kochia management?
9. What is the biggest challenge in getting a grower to adopt researched based management practices, and how can we overcome this (money probably).
10. Why do farmers follow or not follow the advice given to them?
11. How can we make these resources clearer?
12. What are some important things to include in kochia resistance management resources?

What do farmers really need for information resources?
Collier: something we struggle with, maybe the farmer is not the target for this type of information, maybe we should also be looking at consultants and companies
Access is a point as well -

Kent davis: depends on the area and cultural things that make up that area, ie wheat cooperative, made an association, do we get commodity groups involved

The trusted advisor role is the most important part, there needs to be a trust level. Growers trust their consultants
Natalie: farmers are short on time so they want all their resources at their fingertips, are apps a possibility,
Is a curated website good - but need to

Farm journal etc publications that access farmers, developing a relationship with these types of publications
Blog like in CA - weed RIC that put out
Weedsmart - podcast, blog and videos
Charlie: there are several state universities that are leading in these areas, with really good resources for growers to look at
Consolidation of multiple state information that can be collated
vipin: important to have a group of growers involved to consult that can give different insight into the research/ different perspective, large grants can require this kind of input to apply for larger projects
Can increase involvement of growers if they feel like they are involved in the research and planning of their priorities, can help change the direction of funding
This is where having growers involved in the kochia group will help make sure our research is relevant
NIFA always focus on those kinds of involvement, growers

Technooptimism, need to address this -
Charlie: getting new chemistries approved
The thin line between marketing
Robert Bruss: don't want to put something out to do with volatility, our off-target issues are different
Make sure we are aware of other issues in different environments

Kent davis: management of kochia is very system dependant, small rain farmers are going to control very different to say beet growers
No till, strip till all different strategy system - but still have all the other
As a short term option, better to have all the studies up for farmers to read and decide for themselves,
Charlie: important for
Maybe put up research outcomes in a common format like a fact sheet for growers so that research that is done is easier to understand

Todd: what about take action group,
Natalie: weedsmart interview other people, run extension days for growers, GRDC, ACRI where would kochia get their funding from cant all be industry funded because we would want to talk about other priorities other than chemistry

Set up field day to show resistance and practices.

Rui: Model for the farmers to know how to deal with resistance issues, predict how much the growers need to invest/economical outcomes
Starting to work it out in research

1. Grant proposal

· Survey will provide a strong resource to apply for future grants, we can identify areas of research that would probably get funded because we can show it is needed by the growers

· Western IPM want to see are practices changing over time in response to extension, essentially, they want a longitudinal survey to look at grower adoption over time as the most important requirement

· Put this together as a proposal that could form the basis for a grant application

· A focus group ahead of a survey can be valuable in identifying target questions

· Most research done so far has been to the east, has not been done in the West

· Selling points:
  
  a. hasn’t been done in the west

  b. focus on kochia which is unique because it covers the most diverse regions,

  c. multi-year survey

Participants to start work on grant application:

Cody/George/Nevin/Katie/Rand first run at the survey
· Workgroup within a work group project to look at the most effective communication tool to get message out

2. **Longitudinal survey comments**

· Need to have social scientists involved, to develop questions, how and who to distribute the survey to because once it is sent out it cannot be changed

· What should be asked/scope of the survey

· How broad are we testing, can we compare what is being done in different areas, what is successful in some regions and not others regarding outreach and management practices?

· The act of doing the survey can change practices by drawing attention to different methods of control

· Metrics are important, need to have background questions like ‘have you attended meetings before’ are growers who attend these more likely to take on new information from extension

· Will be based around the understanding the sociology and psychology of decisions, ie we choose risk vs benefit in different scenarios

· Question ideas:

  a) Where are people getting their information? why are they going to these places and why do they trust them?

  b) Not only what the participants are doing, but what they think they are doing, what is their perception of their current practices?

  c) forward thinking questions, we know where this group want to move forward with research, we could include this to see if the growers even want this to be done, and can track how well or relevant this research direction is going

3. **Website/information dissemination**

· Model to base on: Weedsmart  https://weedsmart.org.au

· Possible outputs:

  a) Online resources
a. Examples of what poor control looks like to help motivate taking on new information/management, good e.g. is showing how the yield monitor drops as go over a non-controlled patch, could be video

b) Short courses

c) Blog

· Want to put the information under one umbrella, how do this can be flexible

· Lots of sites exist like this, do not want to re-invent the wheel if this is already out there in some form

· Consider that regional information is covered by extension specialists

“Transcript” of session

Kelly: Not only what are they doing but what do they think they are doing, what is the perception of their current practices

George: The act of doing the survey can change practices by drawing attention to different methods of control etc

?: What are we measuring, how broad, what is being done in that area, then can work out what is successful and what is not successful, are some things working in some areas and what are not working, could these work in different areas

Rand: need to have a social scientist to be involved, do develop the questions, how and who to distribute the survey because once it is sent out can’t change

Nevin: There is a survey team at U of Nebraska that can act as a service provider. May be a problem to use as this is through the western IPM

Olivia: should decide what do we want to know, what information do we want

George: use other surveys already done for examples how to structure this one

George: One Q would be where are people getting their information, why are they going to these places and why do they trust
George: we need to be careful as to what we call the survey, if we call it a longitudinal survey it needs to be one, repeated measures/same participants – if you track the same people over time, it is more powerful but more difficult

Rand: we want to look at management practices

Alan: What do you want the survey to accomplish, what is it you want to learn from the survey that will help change our behavior to help us be better communicators/get the message out

Nevin: survey is a strong resource to apply for future grants, we can identify areas of research that would probably get funded because we can say it is needed by the growers

?: Would let us know if our outreach efforts are working, what are areas of adoption of better resistance methods – why are they taking on some but not others is it because if bad communication or because it is just a bad year so farmers are saving on herbicide applications etc

Cody: should include forward thinking questions, we know where this group want to move forward with research, we could include this to see if the growers even want this to be done, and can track how well or relevant this research direction is going

George: Metrics are important, need to have background questions like ‘have you attended meetings before’ are growers who attend these more likely to take on new information from extension, what is the effect

Kelly: Need to compare regionally, ie Canada does not have extension so would not be able to use the same approach. Particularly if we want to contrast and compare

Todd: for this workgroup, western IPM want to see are practices changing over time in response to extension essentially they want a longitudinal survey to look at grower adoption over time as the most important

George: Multi vs long – can overcome it not being long by having a larger sample size with a multiyear, can ask about multiyear questions in the one survey, which is used in cross section surveys problem, if trying to track the same people over time, people drop out so there can be problems

Nevin: depends on the funding, what we are able to do will depend on the grant source

Todd: we agree we want a survey mechanism, we agree this is a high priority and work it I to our plan with this work

Alan: we are back to the understanding the sociology and psychology of the decisions, ie why are we stupid risk vs benefit
?: need to understand decision processes

George: Katie ran focus groups in different states, to get at this decision process, could quantify and organize the responses, in some cases there was commonality in areas and others there was a range of responses. a focus group ahead of a survey can be valuable in identifying target questions

Todd: could use the one rand distributed just before this meeting

Rand: economically and fiscally correct isn’t always aligned with best practices, also need to work to a budget

Todd: could we get a group that could put this together as a proposal that could form the basis for a grant application

Todd: Timeline wise, western IPM funding is due December so we have a timeline

Cody: Could Nebraska be a sub applicant on this because technically they are in the northern IPM

Todd: Can split, part could be survey, part could be administration

George: Most of the research done so far has been done to the east, hadn’t really been done in the west

Todd: Can use the listening sessions

**Cody/George/Nevin/Katie/Rand will take the first stab at the survey**

Kelly: What are the funding options, what would be the best funding sources

George: Selling points – hasn’t been done in the west, focus on kochia, multi year

Nevin: powerful case for kochia being unique because it covers the most diverse regions

Kelly: proposing a proactive stage of management, instead of reflexive

Todd: (about outreach) should we consider consulting an adult education expert, use an Integrated media output podcast/written etc

?: this could become pretty complicated, can’t tell them all the things to do but maybe focus on what not to do

Olivia: Do we want to include regional information, specific to climate /regional zoning information
Nevin: Separate between cropping systems, give specific information for cropping system

Rand: Have internal tool that BASF use for this ie for activating rainfall

Olivia: Perhaps a small version of the decision tool, seems our resources aren’t working as well as we thought they were

Kelly: Awareness is a problem, the information we give may always focus on the same management strategies and not giving other options

Rand: The accessibility of online resources was very important in the survey

Olivia: Perhaps a single place for people to go that has all the resources, and do we separate resources through location, if someone goes to the website, can click on their location and it links you to all the resources for that are for kochia

Todd: A possible model for this could be weedsmart (AU)

General: As well as online resources they also put on short courses, blog.

Nevin: WSSA has one, don’t want to re-invent the wheel because there is a lot of sites like this out there, would it be better to join up on one of the sites and put our data on that website rather than have to host our own

Nevin: we already cover regional information via extension specialists, may not be possible to put it on a site.

Todd: we need to put it under one umbrella (all the information) but how we do this is flexible if we do it on our own or as part of a different site

Alan: is there value in having examples of what poor control costs, to try and increase uptake of new information and help educate on the cost of poor management – would this be effective

Nevin: two schools of thought on decisions, one is we (the growers) don’t know the cost, one is this weed is not acceptable.

George: it is tricky – up front cost they know but if they take a risk, it’s a financial risk

Rand: good example of future cost is showing how the yield monitor drops as you go over a noncontrolled patch – could be a youtube vid

Todd: see a work group within a work group project to look at the most effecting communication tool --- to get our message out, Could it be part of a CAP, area wide project and if we integrate it in with the research part it is a really good candidate for this
Discussion Notes, Western IPM Center Kochia Work Group, 2019

Group C- Eric Westra, Scribe

Members 9:30 AM Discussion
EPW

**Biology and Ecology**

Jens Juras: Low spots are not managed which contribute to seed production at field level
  - Mapping and spectral imaging to direct
Rob: Managing kochia in August, but time of Harvest

Christian: Kochia seed predation (not favorable, potential chemical cues that deter predation)
Christian: Seed coat dynamics on the potential to resist microbial decay (last 5 to 10% of after 2 years)
Charles: Potential pathogens for abscission layer

Action Points: Out of 930 discussion:
Lens: Compare in crop vs non-crop kochia
Lens: Imaging spectral to detect and spot manage resistant populations
Charles: Evaluate impacts of saline soil conditions/ drought stress (low spots tend to have more of these issues)
Charles: planting of saline tolerant forage crops in low field areas to compete with kochia.
Len: How does fall pre, spring pre, in crop post effect resistance development (tank mixtures)

**HR:**
Len: Difference in resistance developemnt between LQ and KS with phenoxyx
Terry: Difference in resistance development between kS and russian thistle (exposed to similar selection pressures)
Len: RNA Seq on phenoxy responses between kochia and LQ
IM:
Len: Physical mowing and subsequent regrowth (seed viability and amounts)
Len: Cutting kochia patches while still green (dealing with field margin kochia populations).
Charles: Silage quality of kochia (sillage before viable seed production) (ability to grow and produce in poor field conditions, potential of multiple cutting per year)
Lens: Can you use different crop stubble to reduce the viability or germination of kochia after.

Integrated Management (11:15 AM Discussion)

Discussion Q's

1. What are some new tools for kochia control? - NOT talking about resistance diagnostics.
   A.) Decision support tool: Do we have enough inputs?
      Time of emergence

Topics from Discussion:
Emergence before planting of crop (flushing out before planting for crops)

Additional crops to rotations, would it limit potential options.
   When adopting new specialty crops is there a reduction in KS control options that impact longer term rotations.

Specialty crops: Is more information needed on kochia impacts in specialty crops for decision making tools input.

Regional differences: Image of crop emergence vs kochia emergence timing for different regions (how small would geographic areas need to be to be relative for growers?)

Fertilizer impacts on sub surface soil layer and kochia germination?
   How does it impact the micro environment for KS germ.

Commercial availability of hwsc options? Grower level or COOP to initiate grower adoption

Decision making tool: PAM for kochia, 10,00 ft view to provide general BMP guidelines (then regional differences can be evaluated) Show impact of general control methods

2. What do growers need the most help with in terms of kochia control?
3. What field metrics should go into a kochia management tool?
4. Integration of machine learning, etc. Would green activated tillage in fallow be useful?
   a. Index weed species with hyperspectral imaging
5. What would be a practical tool to reduce seed set?

6. Cultural, chemical and seed management are the top 3 suggested research areas proposed by the survey. What are some areas in cultural management that can be potential targets for research?

7. How do we use the cropping system to manipulate kochia seed production?
   a.

Ideas/priority topics that nevin got back from survey-
How does environmental spatial variability impact kochia fecundity and longevity
Impact of pre-
Targeted crop rotations
Cover crops and silage crops

Precision AG:

Hyperspectral Imaging:

HWSC:

PAM for KS:
   ● Parameters needed?

IM From 9:15 AM Discussion EPW
Len: Physical mowing and subsequent regrowth (seed viability and amounts)
Len: Cutting kochia patches while still green (dealing with field margin kochia populations).
Charles: Silage quality of kochia (sillage before viable seed production) (ability to grow and produce in poor field conditions, potential of multiple cutting per year)
Lens: Can you use different crop stubble to reduce the viability or germination of kochia after.

**Herbicide Resistance**

“Resistance diagnostics” doesn’t mean IN FIELD diagnostics. We’re talking molecular markers, ppl.
Todd’s lab is making a marker database for KASP that contains all the known SNPs for ALS, ACCase, Gly, etc. resistance mutations.

Certain types of resistance could make it difficult to design a test.

In-field diagnostics exist for blackgrass, BReD works by detecting the glutathione transferase AmGSTF1—a protein that is found in high concentrations in black-grass populations that have evolved resistance to multiple classes of herbicides. (pregnancy style test)

13. Which herbicides should be considered a priority to develop resistance diagnostics for?
   a. ALS, Glyphosate, Auxins, HPPD herbicides (priorities for diagnostics)
   b. Homogeneity of resistance? (1 out of 100) How many individuals to test in a field to determine a population is resistant?
   c. Break down by AI (Multiple)
   d. Generics impact on resistance development. (other companies recommendations)
   e. Jug mixtures at full rates: Impact of relying on a single product.
   f. Treat all growers like the ones that have a problem.
   g. Top end of herbicide rates from companies?

14. Which herbicides should we prioritize in-field resistance diagnostics
15. How can molecular diagnostic tools be integrated into a management plan
16. How can we develop these diagnostics?
17. How can we use field survey data to inform resistance management tools?
18. Should we upkeep kochia seed lots with different phenotypes for researchers?

Len: Difference in resistance developemnt between LQ and KS with phenoxyxs
Terry: Difference in resistance development between kS and russian thistle (exposed to similar selection pressures)

Len: RNA Seq on phenoxy responses between kochia and LQ

1.) How would understanding resistance mechanism influence grower control approaches?
2.) In field resistance diagnostic tools for growers?
3.) Testing prior to applications?
4.) Potential for reversal of resistance mechanisms?
5.) Mutliple MOA Resistance populations (How to deal with Alphabet resistance)
Education and Social Science

13. How effective do you think our current resources are for kochia management?
14. What is the biggest challenge in getting a grower to adopt researched based management practices, and how can we overcome this (money probably).
15. Why do farmers follow or not follow the advice given to them?
16. How can we make these resources clearer?
17. What are some important things to include in kochia resistance management resources?
18. What do farmers need for information resources?

Online resources for conveying academic information

**Next Steps**: simple decision making model as a tool for communication.
Prioritize information to those who the farmers are talking too (local agronomist).
WERA: western extension research activities?
  Look up local
More economic analysis on recommendations
Higher stress level = more techno optimism.
Decision making tool that incorporates full farm decisions, not only weed control

Discussion Notes, Western IPM Center Kochia Work Group, 2019

**Group D- Eric Patterson, Scribe**

Biology and Ecology
Seed Bank longevity - How long is that tail?
  - Driving a seed bank to extinction…. how long does that take?
● Zero threshold concept.
● Need a looooong experiment (10-12 years)
● Dormancy mechanisms? -> water and light, it grows
● Look at withdrawls
  ○ Make seed germinate -> Stale seed bedding?
    ■ PGRs?
    ■ RNA-integrity as a marker for seed viability
    ■ Sync germination
  ○ Smaller seeds -> less vigor, less persistence
    ■ Smaller seeds often in HR plants?
  ○ Post harvest applications for smaller seeds/less viable seeds/less seeds.
    ■ Labeling issues for late applications
● Far-red light insensitive -> Germinates under the canopy
  ○ With small seed bank you must germinate -> got to take a shot
    ■ Molecular mechanisms?
Crop competition
  ○ Very competitive crops (2 years of wheat will reduce seed bank control plants etc., Barley)
    ■ Will germinate in competitive wheat and lose, germinate in corn and do better (canopy/light related)
    ■ Sugar-beet -> Out of tools
      ● Not competitive, must rotate to competitive crops?
    ■ You can make corn more competitive with cultural practices
      ● Trade offs in yield/weed control
      ○
● Fitness penalty
  ○ Long term (does it go away?)
  ○ IF selection pressure decreases does the trait go away or is it latent in the population ready to be selected again
● Traits for crops
  ○ Rhizoctonia resistance in kochia
  ○ Traits have to be worth $$$ for GMO
    ■ Or….can we find those traits in germplasm of crop
  ○ Good germplasm -> big differences in biotypes, not correlated with environment
● Resistance diagnostics

Integrated Management

Discussion Q’s
1. What are some new tools for kochia control? - NOT talking about resistance diagnostics
   ○ Harvest weed seed control - What is the number of viable seeds at time of harvest?
     i. If it's green there is chance for regrowth
     ii. Maybe better in canada?
        1. Corn or dry beans? Maybe ideal timing. Might still be retained but low chance for regrowth -> Combine/header dependent in corn
     iii. Use in conjunction with post harvest herbicide application
     iv. Not going to work in wheat-- Harvest is to early
   ○ Could you delay flowering with a pgr in a post-harvest application (do you have to use an herbicide?)
     i. Trigger fatal germination? Could you give water and light right after harvest and get stuff to germinate in the fall to die in the winter
        1. Dormancy is important here too
     ○ Burst of light to encourage germination (as little as 5sec in lambsquarter)
2. What do growers need the most help with in terms of kochia control?
   ○ Education
   ○ Rotation is great...but its expensive and harder -> compatible tools
     i. Equipment sharing? Quite a few examples
   ○ Go full alfalfa for a while and wipe out weeds.
3. What field metrics should go into a kochia management tool?
   ○ No way a tool would be useful in most systems all at the same time.... it would be huge for all the diverse systems
   ○ Might work for some and not others
   ○ The diversity and complexity means a lot of assumptions... right now it would be all guessing
     i. Might be a great exercise for researchers
        1. Find holes in knowledge know where we need to improve
4. Integration of machine learning, etc.
5. Would green activated tillage in fallow be useful?
   ○ Great for cost but does not improve weed control
     i. If your fields are already so weed free this would work then you don’t have much weed control costs
   ○ To much investment in fallow
   ○ Precision tools will be better in crop then in fallow
6. What would be a practical tool to reduce seed set?
7. Cultural, chemical and seed management are the top 3 suggested research areas proposed by the survey. What are some areas in cultural management that can be potential targets for research?
   ○ Which one makes sense is case dependent
     i. Crop rotational diversity
     ii. Emergence timings
     iii. Market driven
iv. Fundamental understanding of your system, environment, weed biology, crop biology, the market etc...

Ideas/priority topics that nevin got back from survey-
How does environmental spatial variability impact kochia fecundity and longevity
Impact of pre-
Targeted crop rotations
Cover crops and silage crops

Herbicide Resistance

“Resistance diagnostics” doesn’t meant IN FIELD diagnostics. We’re talking molecular markers, ppl.

Todd’s lab is making a marker database for KASP that contains all the known SNPs for ALS, ACCase, Gly, etc. resistance mutations.

Certain types of resistance could make it difficult to design a test.

In-field diagnostics exist for blackgrass, BReD works by detecting the glutathione transferase AmGSTF1—a protein that is found in high concentrations in black-grass populations that have evolved resistance to multiple classes of herbicides. (pregnancy style test)

19. Which herbicides should be considered a priority to develop resistance diagnostics for?
   a.
20. Which herbicides should we prioritize in-field resistance diagnostics
   a. Timing is critical, how much does it cost, how many plants do I need to sample, these aren’t necessary… am I going to find it when it is first developing. I am going to spray glyphosate regardless of resistance. More useful when you have field history. Useful for proving resistance (not just misapplication, missed spot)
21. How can molecular diagnostic tools be integrated into a management plan
   a. Can't realistically be employed preventatively. Its inherently reactive …but it can help year to year.
22. How can we develop these diagnostics?
   a.
23. How can we use field survey data to inform resistance management tools?
   a.
24. Should we upkeep kochia seed lots with different phenotypes for researchers?
   a.
Education and Social Science

19. How effective do you think our current resources are for kochia management?
   a.

20. What is the biggest challenge in getting a grower to adopt researched based management practices, and how can we overcome this (money probably).
   a. Getting all farmers in a community working together. How do we incentivise good practices. Biggest bang for the buck -> Priority list of cost/return
      i. Incremental building on success -> nudging people in the right direction

21. Why do farmers follow or not follow the advice given to them?
   a. Not all people are information searchers; however, all farmers need to be sustainable and profitable, if we can convince them it's in their best interest to do X,Y, and Z. Prioritize biggest bang for our buck.
      i. Lack of critical thinking -> not evaluating on facts
      ii. How long does it take to pay back?
   b. Incentive programs coming from industry not extension/government

22. How can we make these resources clearer?
   a.

23. What are some important things to include in kochia resistance management resources?
   a.