Evaluation of pre-harvest desiccants to reduce viable weed seed production in pulses

Montana State University

Cover Sheet

Organization Information			
Company/Organization Name	Montana State University		
Business/Organization Type (select one)	University/College		
Grant Project Contact	Lovreet Singh Shergill/Montana State University		
Mailing Address	Southern Ag Research Center (SARC), 748 Railroad Highway, Huntley MT 59037		
Physical Address	Southern Ag Research Center (SARC), 748 Railroad Highway, Huntley MT 59037		
Project Information			
Project Title (limited to fifteen words)	Evaluation of pre-harvest desiccants to reduce viable weed seed production in pulses		
Award Request	$149,338		
Project Start Date	09/30/2022	Project End Date	09/29/2025
Crop(s) benefitting from project	Chickpea and Lentils		
Will project benefit beginning farmers?*	Yes	Will project benefit socially disadvantaged farmers?**	Yes
Is this a multi-state project?	No	List partnering state(s)	Montana State University
Does project include market adaptations for COVID-19?	No	If yes, explanation	

*__Beginning farmers__ - individuals or entities who have not operated a farm for more than 10 years and substantially participates in the operation.

**__Socially disadvantaged farmers -__ means a farmer who is a member of a socially disadvantaged group. A “Socially Disadvantaged Group” is a group whose members have been subject to discrimination on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program

Narrative

Abstract

Include a project summary of 250 words or less, suitable for dissemination to the public. It should include:

1. *The name of the applicant organization*
2. *A concise outline the project's outcome(s), and*
3. *A description of the general tasks to be completed during the project period to fulfill reach outcomes.*

Weed seedbanks act as a primary source of annual weed infestations and reduction in seedbank replenishment is critical for long-term weed management. Weed populations that escape herbicide applications due to herbicide resistance, lack of control, or late-season emergence continue to grow and replenish the seedbank. Desiccants are currently being used by pulse growers to improve crop dry-down to optimize harvest timing. However, these applications can aid in reducing weed seedbank replenishment by limiting weed seed production and quality. There is little information on whether various herbicides applied alone or as tank-mix with glyphosate or glufosinate could improve crop dry down and limit weed seedbank replenishment. We propose to conduct field and greenhouse studies at Montana State University to determine the effect of preharvest desiccants on dry down and seed yield of chickpeas and lentils, as well as seed quantity, viability, and germinability of kochia and common lambsquarter. This 3-years research will be conducted at 3 sites across Montana i.e., SARC, Huntley; Post Farm, Bozeman; and NWARC, Kalispell. This study will provide better understanding of preharvest desiccants in relation to crop dry down and weed management.

Project Purpose

1. **What is the specific issue, problem or need**?
   - What is the problem or need that you are trying to address?
   - Why is the project important and timely?
   - What is the importance to specialty crop stakeholders?

Growers have identified weed management, particularly of broadleaf species, as one of the biggest challenges for growing pulses. Kochia (Bassia scoparia (L.) A. J. Scott) and common lambsquarters (Chenopodium album L.) have been identified as the most problematic summer annual broadleaf weeds in pulse crop production (McVay et al. 2013; Yenish 2007). The evolution of multiple resistance in kochia including group 2 and 9 resistances has further complicated the control of this species in pulses. Pulses including chickpea and lentil are poor competitors with weeds and season-long weed interference can reduce crop yields up to 95% (Lyon and Wilson 2005; Smitchger et al. 2012). Pre- and post-emergence herbicides have served as the foundation to control weeds in conventionally grown pulses. However, weeds that escape PRE or POST herbicide application control, due to herbicide resistance, lack of control, or late-season emergence, continue to grow, set seeds, and replenish the seedbank. Seeds can persist in the seed bank for several years depending on species, furthering future weed infestations. Preventing weed seed production is critical to reducing the spread and the costs associated with all weed infestations in cropping systems (Bell and Tranel 2010). Since pulses such as chickpeas and lentils have indeterminate growth habit, growers use desiccants before harvest to dry-down pulse crops, as uniform seed maturity at harvest time is critical to optimize field harvesting and

seed quality. While pre-harvest herbicides in pulses have mainly been used as a crop dry-down, these applications can serve to minimize weed seed contributions to the seedbank by hindering seed development, which may render some weed seeds non-viable. The use of herbicides as desiccants has been shown to reduce weed seed germination the following year in many weed species (Bennett and Shaw 2000; Hill et al. 2016; Zhang et al. 2016). Many producers tank-mix herbicides to use as desiccants for enhanced weed control and dry-down of crop biomass. Growers frequently desiccate pulses at physiological maturity to avoid negatively impacting seed development (Zhang et al. 2016). However, this may not be the ideal time to apply desiccants to reduce weed seed set but may negatively impact weed seed development. Weed competitive ability is directly related to seed size and seedling vigor (Coomes and Grubb 2003; Stougaard and Xue 2004). Therefore, a treatment that leads to reduced seed quality could be a valuable management option even if seed production is unaffected or slightly reduced. There is currently limited information available on the effects of paraquat, flumioxazin, saflufenacil, and pyraflufen-ethyl applied alone or in combination with glyphosate or glufosinate as desiccants for chickpea and lentil dry-down in Montana cropping systems. No information is available on the potential use of desiccants as late-season weed control measures to reduce kochia and common lambsquarters seed set and viability. Systemic herbicides like glyphosate provide great weed control on all weeds with poor crop dry down, while contact herbicides provide greater crop dry down but reduced weed control (Menalled 2009). The addition of these contact herbicides to glyphosate could provide uniform crop desiccation and potentially improve weed control compared to when these herbicides are applied alone. Additionally, glyphosate seed residues may be reduced by the addition of these contact herbicides to glyphosate in a tank mix or using alternative tank mixtures without glyphosate, and these mixtures of herbicides may have different effects on the germination and vigor of subsequent weed populations. Therefore, it is important to determine which desiccants or mixtures of desiccants will provide rapid and uniform chickpea and lentil crop desiccation, have little to no effect on crop seed yield, and have the greatest impact on weed control and seed bank contributions of problem weeds in the following years. This project is very timely as it will help growers develop long-term weed management strategies for weed seedbank management in Montana cropping systems. Late-season herbicide applications would provide growers with an additional tool for managing the kochia and common lambsquarters seedbank. Reduction in seedbank size will eventually lead to a reduction in future weed interventions and the cost associated with weed management.

2. **What are the objectives of the project**? Provide a listing of the objectives that this project hopes to achieve

Objective Name	Objective Description
1) Determine the effect of preharvest desiccants on chickpeas and lentils dry down and seed yield	Field experiments will be conducted across three locations in Montana to assess the efficacy of paraquat, flumioxazin, saflufenacil, and pyraflufen-ethyl applied alone or in combination with glyphosate or glufosinate as desiccants for chickpea and lentil drydown and seed yield. We hypothesize that tank mixing contact herbicides with systemic herbicides will accelerate crop dry down without adversely affecting crop yield. Desiccants will be applied when chickpea and lentil seeds have 30% moisture content or as recommended by the herbicide label. Visual assessments of crop dry down will be taken at weekly intervals after desiccant application. Crop will be harvested to assess the effect of desiccation on yield loss.
2) Determine the effect of preharvest	From the field experiments, we will assess the effect of desiccants on kochia and common lambsquarters seed production and quality. We hypothesize that including

desiccants on kochia and common lambsquarters seed production and viability in chickpeas and lentils	herbicide mixtures will reduce weed seed production and viability. Multiple plants of variable sizes will be collected from each treatment and seed production will be determined on weight basis. Seeds will also be assessed for other quality parameters like seed size, viability, and germinability. A subset of seeds from each treatment will be placed in mesh bags and left in the field to over-winter. The seed samples will be placed on soil surface to mimic no-till and buried under soil to mimic fall tillage. Seed viability and germinability tests will be conducted in the next spring season in the lab.
3) Determine the reproductive growth stage (days after anthesis) at which kochia and common lambsquarters could be desiccated to minimize viable seed production	In year 2 and 3, greenhouse studies will be conducted to evaluate the influence of timing of desiccant application and herbicide mixtures on seed production quality and viability. We hypothesize that the application of desiccants at anthesis will significantly reduce weed seed production, viability, and germinability. Multiple populations of kochia and common lambsquartes will be used in this experiment. If available, we will try to use glyphosate resistant and susceptible accessions for kochia, otherwise susceptible lines will be used for the experiment. Desiccants will be applied at 3 different reproductive stages of kochia and common lambsquarters. The effective treatments from the field experiment will be selected for further assessment in the greenhouse. Assessments of visual dry down at weekly intervals, seed production at harvest, germinability and viability will be recorded. Germinability will be assessed using germination bioassays and viability will be assessed using a tetrazolim test (TZ). We will also monitor the reproductive stages of crop and weeds in the field and use that data to explain phenomenon observed in the greenhouse experiment.
4)	
5)	

Potential Impact

1. **Who are the beneficiaries of the project?** Be as specific as possible, describe the population affected and where they are located. Use statistics to describe the target population.

This project will benefit to Montana and Northern Great Plains pulse growers. It will also provide valuable information for Agricultural Extension Agents as well as undergraduate and graduate students interested in integrated weed management.

2. **How many beneficiaries will be impacted?** The answer to this must include a number.

All producers that grow pulse crops in Northern Great Plains and beyond will benefit from this project. We expect to directly reach more than 1000 growers and ~15,00 Montana Ag Live viewers. Also, 35 undergrad students and 1 graduate studentper year.

3. **How will the beneficiaries be impacted by the project?** Be specific and refer to the target population. Discuss their current condition and how the activities performed will improve that condition.

Herbicide resistance and increased weed challenges and production costs threatens the sustainable production of pulse crops in Montana. In this context, developing integrated weed management strategies is at the core of maintaining the economic sustainability of the farming enterprise. The information generated in this research will benefit pulse growers by providing them with management strategies to minimize inputs to the seedbank.

Outreach

Describe how you will share the results of the project with specialty crop growers and other interested specialty crop stakeholders.

Drs. Shergill and Beiermann have an extension component with their appointment and work extensively with growers in Montana. New and pertinent information on production practices relevant to growing pulse crops will be added to MonGuides. Results of this project will be shared through Montana Grain Growers, Montana Pulse Day, and county level extension meetings, field days, flyers, scientific and extension publication. Preliminary and ongoing findings from this work will be shared with producers in multiple ways, including field day presentations and winter grower meetings; news releases and slide show presentations on the MSU websites (http://sarc.montana.edu/ and https://agresearch.montana.edu/nwarc/index.html) and social media outlets; and electronic newsletters published by the Montana State University.

External Project Support

Describe the individuals and organizations that support the nature of the support they are providing.

1. Chickpea and lentils seed will be provided by Great Northern Ag. They are a seed retail company and support the promotion and adoption of pulses in the region. This research will aid in answering questions about specialty crops desiccation and improve adoption in the region. They will not get any direct benefit from the project. 2. Experimental herbicides will be supplied by Bayer, BASF, Gowan, Valent, BASF, and Syngenta. They support herbicide research in specialty crops and these sites will act as demonstration sites for growers. They will not get any direct benefit from the project. 3. Montana State University research centers and Northern Pulse Growers Associations organize field days/conferences in Montana to disseminate information regarding pulse crop production where we will present results through oral presentations, annual reports, and extension publications. 4. Montana pulse producers have shown lot of interest in this research during some of our extension meetings. 5. Local Farmers in our advisory already growing these crops need information for weed management. 6. Dr. Lovreet Shergill, MSU Southern Agricultural Research Center (SARC), will serve as the Project Director (PD), will assume full administrative responsibility for the project, and will direct all activities related to design, implementation, management, and dissemination of project results. Dr. Shergill will oversee field, greenhouse, and lab research and will manage communication with collaborators at field sites, oversee all project staff at SARC, and provide mentoring and professional development to students. Dr. Shergill will work with co-PDs and collaborators to prepare and document data files that report results to the broader research community. Dr. Shergill will also share results with producers through grower meetings.

7. As a Co-PD, Dr. Clint Beiermann, MSU Northwestern Agricultural Research Center (NWARC), will collaborate in field activities and will direct research trials at NWARC. Dr. Beiermann will assist in data analysis and will present results at various grower meetings.
8. As a Co-PD, Dr. Fabian Menalled, MSU Dept. of Land Resources and Environmental Sciences, will collaborate in the field and greenhouse activities of this project, will participate in the data analysis and presentations at Professional meetings, and will incorporate the results of this study into the Weed Ecology and Management course he teaches.

Eligibility

By marking the box below, I confirm that this project enhances the competitiveness of specialty crops in accordance with and defined by 7 U.S.C. 1621. Further information regarding the definition of a specialty crop can be found at www.ams.usda.gov/services/grants/scbgp.

Yes	X

Previous Efforts

Does the project build on a previously funded SCBG project?
No

If YES,

1. Describe how the project differs from and builds on the previous project.

2. Provide a summary (3 to 5 sentences) of the outcomes of the previous project(s).

3. What was learned from implementing this project, including potential improvements?

4. How are the lessons-learned being incorporated to make the ongoing project more effective and successful at meeting goals and outcomes?

5. Describe the likelihood of your efforts becoming self-sustaining and not indefinitely dependent on grant funds.

Support from Other Federal or State Grant Programs

Did you submit this project to a Federal or State grant program other than the SCBGP for funding and/or is a Federal or State grant program other than the SCBGP funding the project currently?

No

If YES,

- Identify which Federal and/or State grant program
- Describe how the SCBGP project differs from or supplements the other grant program(s) efforts.

Project Funding

Provide the following information in this section:

Could the outcomes of this project be accomplished with a reduced budget?

Yes, we would accept a reduced amount, with corresponding reductions in outcomes.

If NO, you are indicating that the project could not be accomplished with a reduced budget (i.e. the funding decision must be "all or nothing").

If YES, indicate which areas of the project could be cut and any resulting changes in project outcomes.

Explain:	Objective 3 of the study could be cut. The remaining 2 objectives will be still accomplished as they are not dependent on this objective.

Citations (Optional)

A list of citations may be added to the application but is strictly optional.

Bell MS, Tranel PJ (2010) Time Requirement from Pollination to Seed Maturity in Waterhemp (Amaranthus tuberculatus). Weed Science 58:167-173
Bennett AC, Shaw DR (2000) Effect of Preharvest Desiccants on Weed Seed Production and Viability. Weed Technology 14:530-538

Coomes DA, Grubb PJ (2003) Colonization, tolerance, competition and seed-size variation within functional groups. Trends in Ecology & Evolution 18:283-291
Hill EC, Renner KA, VanGessel MJ, Bellinder RR, Scott BA (2016) Late-Season Weed Management to Stop Viable Weed Seed Production. Weed Science 64:112-118
Lyon DJ, Wilson RG (2005) Chemical Weed Control in Dryland and Irrigated Chickpea. Weed Technology 19:959-965
McVay K, Burrows M, Menalled F, Jones C, Wanner K, O'Neill R (2013) Montana cool-season pulse production guide. Bozeman, MT: Montana State University Extension. Pp. 28
Menalled F (2009) Integrated weed management in lentils. Bozeman, MT: Montana State University Extension MontGuide MT201009AG
Smitchger JA, Burke IC, Yenish JP (2012) The Critical Period of Weed Control in Lentil (Lens culinaris) in the Pacific Northwest. Weed Science 60:81-85
Stougaard RN, Xue Q (2004) Spring wheat seed size and seeding rate effects on yield loss due to wild oat (Avena fatua) interference. Weed Science 52:133-141
Yenish J (2007) Weed management in chickpea. Pages 233-245 in Yadav S, Redden R, Chen W, Sharma B, eds. Chickpea breeding and management. UK: CAB International
Zhang T, Johnson EN, Willenborg CJ (2016) Evaluation of Harvest-Aid Herbicides as Desiccants in Lentil Production. Weed Technology 30:629-638