Strategic Field Program (SFP)

Project Progress Report

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| Project Title: | Cultural and Agronomic Management of Weeds in Annual Crops with an Emphasis on Kochia |
| SFP File Number: | 20230578 |
| Reporting Period: | April 1, 2024 to December 10, 2024 |

# Principal Investigator

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# Abstract

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| The following project is funded by the Saskatchewan Ministry of Agriculture and Agriculture and Agri-Food Canada. Herbicide resistance in kochia costs farmers in Saskatchewan millions of dollars annually.[[1]](#footnote-2) This project will help raise producer awareness of ways to manage weeds on their farms with equipment and cultural practices through the evaluation of three objectives. First, if light tillage in the spring, fall, or both timings promotes weed seed germination, therefore those weeds can be controlled in the spring by herbicide application, or a seeding pass. Second, to measure the impact on weed competition of fall seeded cereal crops versus spring seeded cereal crops and lastly, to investigate if growing annual crops and cutting them for green feed reduces future weed pressure. The trials were initiated at both Swift Current and Redvers in 2024. In the first year of the project crop emergence was lower than the targeted plant stands due to the large kochia populations present at seeding. At Swift Current, there was no relationship between harrowing and kochia plant health, or population. However, there could be a cumulative effect from harrowing in the following years. Fall cereals were seeded at both locations into dry soil following a canola crop. At Swift Current, the kochia population was lower after fall seeding, than it was a few weeks prior, after harvest, but the number of other weeds increased. Kochia generally increased throughout the growing season for each objective. However, very few other weeds were present until after harvest. The project will continue for three more growing seasons and a final report will be available December 2027 and this progress report only includes data from Swift Current. |

# Introduction

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| Herbicide resistance in kochia takes approximately ten years to spread over a wide area (Charles Geddes, personal communication, September 2023) and a significant percentage of kochia populations will likely be resistant to Group 4 products by this project’s completion. Group 14 resistance has recently been confirmed and will continue to spread if kochia management practices remain the same[[2]](#footnote-3). The results of this project will allow collaborators, agronomists, and producers to have more information on ways to control herbicide-resistant kochia and other weeds without relying entirely on herbicides. By having the project target kochia and including data collection on other weeds as well, insights into the control of other weed species will be gained. All practices included in the project are relevant and can be implemented on-farm.  Weed control studies, especially on kochia, need to be conducted at multiple sites in western Canada over multiple years. Herbicide resistance in kochia costs farmers in Saskatchewan millions of dollars annually, and this resistance cannot be reversed. Conducting research at multiple sites over multiple years is crucial for a problem as significant as this one. This project aims to complement research already being conducted in Lethbridge, Alberta and Scott, SK (Dark Brown soil zone).    Tom Wolf, partner at Agrimetrix Research & Training, states that “farmers must prepare for a time when they’ll have fields where they cannot deal with a persistent weed in a chemical way at all because of resistance[[3]](#footnote-4).” He continues that it is already a reality for some farmers in North America and Australia that have resorted to cultural control methods. This project will help raise producers' awareness of ways to manage weeds on their farms with equipment and cultural practices through the evaluation of three different objectives. Objective 1: Determine if light tillage in the spring, fall, or at both timings promote seeds to germinate and be controlled in the spring by herbicide application or seeding pass  * Dr. Charles Geddes has observed that kochia plants cut off at harvest are still viable below where they were cut with the combine cutter bar and still produce approximately 2,000 seeds per plant. The remaining plant will be killed by frost in the fall but will leave a mat of dried kochia plants that can cover and protect germinating seedlings in the spring. The tissue mat may prevent liquid herbicide applications from reaching the soil surface in the fall and spring as all fall-applied herbicides for kochia are liquid formulations except for one (ethalfluralin). * However, a tillage operation in the fall or early spring could break up the kochia mats. A common weed control practice for organic crop producers is to till a field in the spring to promote weed germination. The resulting weeds can be controlled by a second spring tillage pass or during seeding.  Objective 2: Measure the impact of winter cereal crops versus spring cereal crops for weed competition  * A previous Strategic Field Program project, “Alternative Strategies for Control and Management of Kochia,” found that spring cereals competed similarly, or better than winter cereals in a three-year rotation with one full crop rotation of canola-cereals-lentils, or peas at one location. However, these results were inconsistent with other Western Canadian studies where winter cereals outcompeted spring cereals. * We want to compare winter cereals and spring cereals for their competitive ability with weeds to see if the result of the initial SFP project are confirmed in Swift Current and Redvers, or if the result from the previous project is an anomaly. * Instead of having a three-year rotation, we will have Roundup Ready canola grown in the first year to maintain, or possibly increase weed pressure and have winter and spring cereals in the project's second year. We will repeat the sequence in Year 3 and 4 with lentils, followed by winter and spring cereals.  Objective 3: Investigate if growing annual crops and cutting them for green feed reduces weed pressure  * Kochia has been successfully fed to cattle when weed populations are high, as long as it remains as only 40-50% of their diet. The majority of kochia seeds are controlled when they move through the cattle’s digestive tract. Targeting kochia by cutting it with green feed for cattle while it is immature could be an excellent way to control or manage kochia and other weeds and provide cattle feed of acceptable quality. Ministry of Agriculture specialists must have reliable and replicated data when discussing weed control with green feed. * If the producer doesn’t have cattle, or a way to sell the crop and weeds for feed, it may be possible to use the crop as a green manure as a way to sequester carbon. |

# Objectives and Progress

**Objective Progress** *(i.e., completed/in progress)*

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| Determine if light tillage in the spring, fall, or at both times promote seeds to germinate and be controlled in the spring by herbicide application or seeding pass. | In progress |
| Measure the impact of winter cereal crops versus spring cereal crops for weed competition. | In progress |
| Investigate if growing annual crops and cutting them for green feed reduces weed pressure. | In progress |

# Project Changes

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| * Objective 2: The crop in year one was changed from lentils to a Roundup Ready canola (or Truflex variety controlled without Liberty) to potentially increase the kochia population before comparing spring and winter cereals. We also wanted to improve the crop rotation from lentil-cereal-lentil-cereal to canola-cereal-lentil-cereal. We still have the spring versus winter cereal comparison twice in four years.   **Note: Redvers data not received in time to be included in the progress report.** |

# Methodology

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| Field trials were established near Swift Current (Light Brown soil zone) and Redvers, Saskatchewan (Dark Grey soil zone) in the spring of 2024. The project consists of three objectives to investigate the impact of cultural and agronomic practices on reducing the impact of weeds on annual crops. Each objective is a separate Randomized Complete Block Design with four replications. Kochia will be the primary focus of this project. However, the overall effect of these treatments on both grassy and broadleaf weeds will be measured. Objective 1: Determine if light tillage in the spring, fall, or at both times promotes seeds to germinate that can be controlled by fall frost or spring herbicide application and/or seeding pass.  * Light tillage at Swift Current was applied using a flex chain harrow. * Light tillage at Redvers was applied using a spring tine harrow.   **Table 1. Treatment List.**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | # | 2024 | 2025 | 2026 | 2027 | | Lentil | Durum | Liberty Link Canola | Lentil | |  | Light tillage using harrow | | | | | 1 | no | no | no | no | | 2 | spring | no | no | no | | 3 | spring | spring | no | no | | 4 | spring | spring | spring | no | | 5 | spring | spring | spring | spring | | 6 | no | fall | no | no | | 7 | no | fall | fall | no | | 8 | spring | fall | no | no | | 9 | spring | fall | fall | no | | 10 | spring | fall | fall | spring | | 11 | spring + fall | no | no | no | | 12 | spring + fall | spring + fall | no | no | | 13 | spring + fall | spring + fall | spring + fall | no | | 14 | spring + fall | spring + fall | spring + fall | spring |   The following data is to be collected for explanatory purposes and to evaluate treatment success in Objective 1:   1. **Weed Density before spring tillage:** count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 2. **Weed Density after spring tillage:** (before seeding), count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 3. **Plant Density:** When emergence is complete, record the number of plants (2 x 50 cm) and convert the values to plants/m2 to assess overall establishment across sites. 4. **Weed Density and Biomass before harvest: C**ount and biomass 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. Dry and weigh kochia before adding collected weeds back to the plot. Dry weight of Kochia will give an idea of kochia plant health. A mat of kochia (high count, low biomass) versus large vertical plant (low count, high biomass). 5. **Grain Yield:** Samples are corrected for dockage, dried to a uniform moisture content prior to weighing and adjusted for moisture content (lentils 13%, durum, 14.5%, canola 10%). 6. **Weed Density before fall tillage:** Count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 7. **Weed Density after fall tillage:** (before freeze-up), count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 8. **Weather Data:** Report monthly average temperatures and total precipitation amounts relative to the long-term averages. Note any significant or unusual weather events that may affect the project results (i.e., extreme rain, hail, early frost).  Objective 2: Measure the impact of winter cereal crops versus spring cereal crops for weed competition.  * Roundup Ready canola (or a Truflex variety controlled without glufosinate) was seeded in year one to potentially increase the population of kochia before comparing spring and winter cereals for weed control in the following year. * Herbicide selection is up to the location based on usual practices.   + All crops will have an in-crop herbicide application to control kochia.   + For winter cereals, a post-harvest application may be made around the same time as the pre-harvest application in the spring cereals.   **Table 2. Treatment List.**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | # | 2024 | 2025 | 2026 | 2027 | | 1 | RR canola | spring wheat | lentil | spring wheat | | 2 | RR canola | winter wheat | lentil | winter wheat | | 3 | RR canola | spring triticale | lentil | spring triticale | | 4 | RR canola | winter triticale | lentil | winter triticale | | 5 | RR canola | hybrid fall rye | lentil | hybrid fall rye |   The following data is to be collected for explanatory purposes and to evaluate treatment success in Objective 2:   1. **Weed Density before spring seeding:** Count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 2. **Spring Plant Density:** When emergence is complete, record the number of plants (2 x 50 cm) and convert the values to plants/m2 to assess overall establishment across sites. 3. **Grain Yield:** Samples are corrected for dockage, dried to a uniform moisture content prior to weighing and adjusted for moisture content. 4. **Weed Density after harvest:** (before fall seeding), count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 5. **Weed Density after fall seeding (2024):** (before freeze-up), count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 6. **Weather Data:** Report monthly average temperatures and total precipitation amounts relative to the long-term averages. Note any significant or unusual weather events that may affect the project results (i.e., extreme rain, hail, early frost). 7. **Weed Density and Biomass before harvest (2025):** Count and biomass 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. Dry and weigh kochia before adding collected weeds back to the plot. Dry weight of Kochia will give an idea of kochia plant health. A mat of kochia (high count, low biomass) versus large vertical plant (low count, high biomass).  Objective 3: Investigate if growing annual crops and cutting them for green feed reduces weed pressure  * Lentils were seeded in year 1 and harvested for grain yield. * Cutting for green feed will take place using a forage harvester to biomass the whole plot in year 2. * Mowing after the crop is cut for green feed will be included as a treatment to demonstrate an option for producers that do not want to use tillage to control kochia as a result of potential soil moisture loss. * In-crop herbicide selection will be up to the location based on safety for green feed, and re-cropping lentils in the next growing season. The number of days between application and cutting for feed will be considered to ensure the application is a reasonable practice according to the [Complete Guide to Crop Protection - 2024](https://publications.saskatchewan.ca/api/v1/products/77706/formats/87089/download). * Timing for green feed harvest will be the soft dough stage for wheat, barley and triticale and late milk stage for oats.   **Table 3. Treatment List.**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | # | 2024 | 2025 | 2026 | 2027 | |  | **grain harvest** | **forage harvest** | **grain harvest** | **forage harvest** | | 1 | Lentil | spring triticale | Lentil | spring triticale | | 2 | Lentil | winter triticale | Lentil | winter triticale | | 3 | Lentil | barley | Lentil | barley | | 4 | Lentil | pea/oat mix | Lentil | pea/oat mix | |  | **grain harvest** | **forage harvest followed by mowing** | **grain harvest** | **forage harvest followed by mowing** | | 5 | Lentil | spring triticale | Lentil | spring triticale | | 6 | Lentil | winter triticale | Lentil | winter triticale | | 7 | Lentil | barley | Lentil | barley | | 8 | Lentil | pea/oat mix | Lentil | pea/oat mix |   The following data is to be collected for explanatory purposes and to evaluate treatment success in Objective 3:   1. **Weed Density before spring seeding:** Count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 2. **Plant Density:** When emergence is complete, record the number of plants (2 x 50 cm) and convert the values to plants/m2 to assess overall establishment across sites. 3. **Weed Density before harvest (2024):** Count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 4. **Grain Yield (2024):** Samples are corrected for dockage, dried to a uniform moisture content prior to weighing and adjusted for moisture content. 5. **Weed Density after harvest:** (before fall freeze-up), count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. 6. **Weather Data:** Report monthly average temperatures and total precipitation amounts relative to the long-term averages. Note any significant or unusual weather events that may affect the project results (i.e., extreme rain, hail, early frost). 7. **Weed Density and Crop/weed Biomass before harvest (2025):** Count 0.25m2 (front and back), reporting kochia as one number and all other weeds as one number. Both the crop and weeds will be biomassed. Report the dry weight of the crop and weeds separately and later combine for quality feed test (A&L Complete Forage Package, F2). 8. **Days to harvest (2025):** Using a Julian Calendar to determine differences in days to forage harvest. 9. **Forage Yield (2025):** Harvest the whole plot using a forage harvester. Report dry weight in kg/ha. Make sure to collect a subsample and weigh wet and dry (for moisture determination if the wet weight was not collected during the pre-harvest biomass. |

# Results

## General Conditions

Early spring topsoil moisture conditions improved in both the Southwest and Southeast after receiving precipitation in April and seeding was off to an early start (table 4). Spring harrowing took place prior to a rainfall and was followed by a number of welcomed showers. A full list of dates and operations at each location can be seen in tables 6-7 in the appendices. These particular trials were seeded later in the growing season as conditions were cool and windy throughout spring, but plots were seeded into good soil moisture. Varying stages of development existed heading into June and there were some crops behind the normal stages and development due to the cooler temperatures experienced and rainfall delays during seeding. Heavy winds were observed, but no crop damage was noted through May and June. Precipitation continued through June until the July long weekend when plots were already a few days into flowering. July and August brought extreme heat and drought and soil conditions rapidly declined while kochia began to thrive. Warm temperatures rapidly advanced crop maturity with some crops showing reductions to yield potential very early on. Both lentil and canola plots were showing symptoms of stress that negatively impacted pod fill. Flea beetles and grasshoppers were present, but pressure remained low as the plots were harvested.

**Table 4. Mean monthly temperature and precipitation for the 2024 growing season (April-September) at Saskatchewan trial locations and long-term (10-year) averages.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Location** | **Year** | **April** | **May** | **June** | **July** | **August** | **Sept** | **Avg. / Total** | **% of Avg. / Total** |
|  |  | *----------------------------------------------------------------Mean Temperature (°C) -----------------------------------------------------------------------* | | | | | | | |
| Swift Current | 2024 | 7 | 11 | 14 | 21 | 19 | 17 | 14.9 | 107% |
|  | **Long-term** | **4** | **12** | **16** | **19** | **19** | **14** | **13.8** |  |
| Redvers | 2024 | **5** | 11 | 15 | 20 | 18 | 16 | 14.1 | 88% |
|  | **Long-term** |  | **11** | **16** | **19** | **18** |  | **16.0** |  |
|  |  | ----------------------------------------------------------------- *Precipitation (mm)* ------------------------------------------------------------------------ | | | | | | | |
| Swift Current | 2024 | 22 | 74 | 52 | 19 | 18 | 48 | 233 | 89% |
|  | **Long-term** | **22** | **43** | **60** | **56** | **40** | **37** | **260** |  |
| Redvers | 2024 | 20 | 92 | 156 | 13 | 39 | 71 | 391 | 124% |
|  | **Long-term** | **20** | **60** | **85** | **66** | **47** | **37** | **315** |  |

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| Objective 1: Determine if light tillage in the spring, fall, or at both timings promote seeds to germinate and be controlled in the spring by herbicide application or seeding pass A tillage operation in the fall or early spring could break up existing kochia mats and promote germination (figure 1). For organic producers the resulting weeds could potentially be controlled by a second spring tillage pass or during seeding. For conventional farmers, the resulting germinated kochia could be controlled by herbicide application in fall, or before seeding in spring.    Figure 1. Kochia mat (left) versus adult kochia (right).  Kochia populations were high and naturally sporadic across the project area ranging from 1-10 kochia/ft2 and 0-1 weeds/ft2 before the spring harrow application took place in Swift Current (April 16, 2024) on select plots (table 5). Following the spring harrow, there was no pre-seed herbicide application in order to measure the effect of harrowing on weed control and to increase kochia in the project. Five weeks later, before seeding, kochia was counted again and had increased whether plots were harrowed, or not (3-16 kochia/ft2), but no other weeds were present. Three weeks after seeding (3WAS), lentil populations were counted and resulting emergence was lower than the targeted plant population of 12 plants/ft2 (9-12 plants/ft2) due to the large amount of kochia present at seeding. However, kochia decreased after seeding to 1-5 kochia/ft2 and remained steady throughout the growing season for both harrowed and non-harrowed plots. This is partly due to the lentil crop creating in-season competition and a post-emergent herbicide application in June.  **Table 5. Swift Current weed counts, plant counts and yield (2024).**    Before harvest, kochia was bio-massed and weighed at the same time as kochia counts. The dry weight of kochia in combination with the counts of the same area was used as a measure of kochia plant health. A mat of kochia where there is a high count and low biomass is thought to produce fewer seeds than a large adult plant. Therefore, a low count with a high biomass likely has a lot of seeds. In year one, there was no obvious relationship between spring harrowing and kochia plant health. The dried kochia was added back into the plot, so as not to remove the kochia seeds from the test area.  Lentil plots were harvested on August 19, 2024 and yield was poor (425-639 kg/ha) due to the high kochia population. Compared to other trials at the same site this was an estimated 50% yield loss. The kochia and weed population was the same after harvest as prior to harvest (1-5 kochia/ft2, 0 other weeds/ft2). Select plots were harrowed again after harvest and weed counts (August 23, 2024). Weeds were counted once more before fall freeze up (October 10, 2024). There were no germinated kochia plants throughout the trial, but other weeds such as volunteer durum and lamb’s quarters increased from zero to 1 weed/ft2 on plots that were not harrowed in the fall. Plots that were harrowed in the fall increased from zero to 1-2 weeds/ft2.  A durum variety suited to each area will be seeded in the spring of 2025 and is expected to better compete with the kochia population compared to lentils. Select plots will receive a spring and/or fall harrow for the second time and others will only receive a fall harrow after harvest. Plots will also receive a spring herbicide application once the weeds present during the spring harrow have germinated, but before seeding. Objective 2: Measure the impact of winter cereal crops versus spring cereal crops for weed competition Winter cereals and spring cereals are being compared for their competitive ability with weeds in Swift Current and Redvers. Canola was grown and harvested for grain yield in the first year to maintain, or possibly increase weed pressure.  Canola plant establishment was on the low end of the target plant population of 5-8 plants/ft2 (5-6 plants/ft2) due to very high kochia pressure throughout the season (6-9 kochia/ft2) and very few other weeds were present (0 weeds/ft2). The resulting canola yield was also poor in part due to the poor kochia control, as well as drought and extreme heat (94-104 kg/ha). Compared to other canola trials at the same site this is an estimated 80% yield loss.  A fall herbicide application was applied after harvest to control any new kochia plants before seeding fall treatments. Fall seeded cereals included Wildfire winter wheat, Snowcat winter triticale and Trebiano fall rye. Fall seeded crops were seeded into dry soil on August 30, 2024. Emergence was delayed until September 25, 2024 following a rainfall event. The kochia population before fall freeze up (0-1 kochia/ft2) was much lower than it was after harvest (6-9 kochia/ft2), but the number other weeds increased (1-2 weeds/ft2).  Spring wheat and spring triticale will be seeded in the spring of 2025 and weed populations in these plots will be compared to fall seeded plots throughout the season. Objective 3: Investigate if growing annual crops and cutting them for green feed reduces weed pressure Similar to previous objectives, resulting lentil emergence was low (9-11 plants/ft2) due to a large kochia population that existed before seeding (3-11 kochia/ft2) and kochia increased throughout the growing season (5-12 kochia/ft2). However, very few other weeds were present throughout the season (0 weeds/ft2).  Lentil yields were also poor ranging from 261-329 kg/ha. Compared to other trials at this site this was estimated to be a 70% yield loss. The kochia population remained high heading into the fall before freeze up (3-9 plants/ft2) with very few other weeds present (0 weeds/ft2).  Spring triticale, winter triticale, barley and a pea/oat mix will be seeded in the spring of 2025 and harvested for green feed. Kochia will be controlled throughout the growing season, keeping acceptable harvest intervals in mind when choosing herbicide options. Any kochia that is present at the time of forage harvest will be included in the feed sample and tested for feed quality. Mowing after the crop is cut for green feed will also be included as a separate treatment to demonstrate an option for producers that do not want to till, or harrow to control kochia due to potential soil moisture loss. |

# Interim Conclusions

Describe the interim conclusions.

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| As seen in previous research and in the field, a high kochia population causes devastating yield losses. Overall, a kochia population of 1-5 kochia/ft2 (10-54 kochia/m2) in small red lentil plots caused an estimated 50% yield loss. When the population increased to 5-12 kochia/ft2 (54-129 kochia/m2) a 70% yield loss was observed. In canola plots, populations of 6-9 kochia/ft2 (65-97 kochia/m2) caused an estimated yield loss of 80%.  There was no obvious relationship between spring, fall, or spring and fall harrowing and kochia plant health or population in year one. However, there could be a cumulative effect from harrowing at different times in the following years. A fall herbicide application was applied after harvest to all objectives to control any new kochia plants. Plots that were seeded in the fall had a much lower kochia populations after seeding compared to after harvest, but the number of other weeds increased. |

# Knowledge Transfer Activities

List any knowledge transfer activities undertaken in relation to this project. Include presentations, talks, papers published in science journals or other magazines etc.

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| * The project objectives were introduced by Amber Wall on a weekly radio show that is broadcasted to the entire Southwest of the province across 3 different radio stations and is titled, “Walk the plots.” |

# Contributions and Support

Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

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| * AAFC Lethbridge is no longer an additional site for the project due to Charles Geddes project workload, but would still be a speaker for extension at events such as Cropportunities. * At his request, Cory Jacob has been removed from the Collaborators and Co-investigators (Internal) since the concept application stage to assist in managing his workload. * Funding support from additional sources is not expected, but several industry experts and commodity groups have identified herbicide resistance as a significant problem, especially in kochia and wild oats. |

# Appendices

Identify any changes expected to industry contributions, in-kind support, collaborations or other resources.

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| * Note that Redvers 2024 will be included when received. |

**Table 6. Wheatland Conservation Area (WCA) dates of operations at Swift Current, SK. 2024**



**Table 7. South East Research Farm (SERF) dates of operations at Redvers, SK. 2024**



n/a – data collection was not completed

\*a small area was harvested and the plots were mowed due to the high kochia population

\*\*Due to a calibration error canola was seeded lower than the targeted 5lbs/ac

1. Charles M. Geddes, Mattea M. Pittman, Shaun M. Sharpe, and Julia Y. Leeson. 2024. Distribution, frequency, and impact of herbicide-resistant weeds in Saskatchewan. *Canadian Journal of Plant Science*. **104**(5): 495-513. <https://doi.org/10.1139/cjps-2024-0017> [↑](#footnote-ref-2)
2. Shaun M. Sharpe, Julia Y. Leeson and Charles M. Geddes. 2023. Kochia Resistance Update: Results from the 2019 to 2023 Glyphosate, Dicamba, and Fluroxypyr-Resistant Kochia Prairie Surveys. https://saskpulse.com/resources/kochia-resistance-update-results-from-the-2019-to-2023-glyphosate-dicamba-and-fluroxypyr-resistant-kochia-prairie-surveys/ [↑](#footnote-ref-3)
3. Real Agriculture (October 23). https://www.realagriculture.com/2023/10/the-agronomists-ep-129-spot-spraying-to-save-money-with-tom-wolf-and-carl-deconinck-smith/ [↑](#footnote-ref-4)