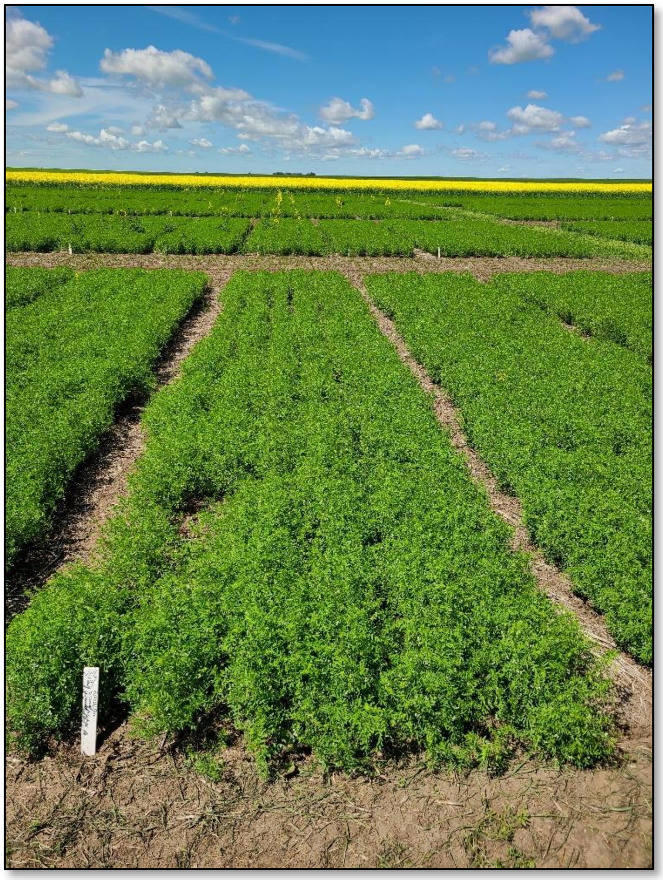
Project: AP2001a

2020 Annual Report

for the

Agriculture Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Herbicide Management Strategies for Weed Control in Lentil (Project AP2001a)



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Project Identification

1. **Project Title:** Herbicide management strategies for weed control in lentil
2. **Project Number:** AP2001a
3. **Producer Group Sponsoring the Project:** Saskatchewan Pulse Growers
4. **Project Location(s):** Scott, Saskatoon, Redvers, and Swift Current, SK.
5. **Project start and end dates (month & year):** October 2019 to September 2020
6. **Project contact person & contact details:**

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Objectives and Rationale

7. Project Objectives:

1. To demonstrate herbicide weed control options for kochia, wild mustard and volunteer canola in lentil
2. To demonstrate herbicide layering technique for lentil
3. To demonstrate the importance of planning ahead and use of fall herbicide application
4. To provide a platform to discuss herbicide resistance management through herbicide rotation

8. Project Rationale:

Weed management has been a long-lasting challenge for producers. Herbicides are the most effective tool used by producers to control weeds. In lentils, the most used herbicide weed control strategy is to use a non-selective pre-seed application (pre-seed burn off) or in-crop application of group 2 herbicides (imidazolinones/sulfonylureas). The prevalence of Group 2 resistant weeds such as wild mustard (McVicar et al. 2010), kochia (Heap 2010), and stinkweed

(Beckie et al. 2007) has resulted in challenges in weed control. Furthermore, Group 2, 4 and 9 resistant kochia populations recently have been identified in Alberta (Beckie et al. 2019), adding more challenges to weed control. This is an evident problem in lentil which is less competitive and has less weed control options. As such a concern is close to our border, improved weed management strategies are necessary to reduce the likelihood of resistance developing in the regions where it is not yet widespread. Altering herbicide types and timing of application can be useful to both reduce the risk of developing herbicide resistance as well as to provide adequate weed management. In particular, herbicide layering with fall applied soil-residual herbicides combined with pre-seed or in-crop application of herbicide can be a potential strategy to overcome the potential future threats. Therefore, the intended benefit of this demonstration is to highlight the different herbicide combinations available to producers and discuss the benefits of multiple modes of actions on the potential of reducing the risk of herbicide resistance development.

Methodology and Results

9. Methodology:

Site Description:

Field experiments were conducted in 2020 at four locations in Saskatchewan: Saskatoon, Scott, Swift Current, and Redvers. All sites were on black chernozem soil.

Experimental Procedure:

The study consisted of sixteen (16) herbicide treatments with different herbicide application timings (Table 1). Fall application of herbicides was applied from mid to end of October on canola stubble in 2019, Spring application (Pre-plant) in 2020, and in-crop application in 2020 (Table 2). Herbicides used in fall application were; Edge (ethafluraflin), Heat LQ (saflufenacil), Fierce (flumioxazin+ pyroxasulfone), Valtera EZ (flumioxazin), Express SG (tribenuron), and Focus (pyroxasulfone + carfentrazone). Herbicides used in spring pre-plant application were Focus (pyroxasulfone + carfentrazone), Goldwing (pyraflufen +MCPA), Valtera EZ (flumioxazin), Zidua (pyroxasulfone), Focus (pyroxasulfone + carfentrazone), and Heat LQ (saflufenacil). All spring application treatments were tank-mixed with glyphosate. In-crop herbicide SOLO (imazamox) was considered as the control. The experimental design was a randomized complete block design (RCBD) with four replicates.

Plots were 1.5 x 8m and cross-seeded with kochia (Scott, Saskatoon, and Swift Current), Clearfield mustard to simulate Group 2 resistant wild mustard (all sites), and canola (all sites). A natural weed strip was also left to cover off normal weed pressures. Actual seeding dates are reported in Table 2.

CDC Impulse lentils (small red Cl variety) was sown at 3 cm seeding depth one day after spring pre-plant herbicide application targeting 180 plants m^{-2} (Table 2). Granular inoculant was used at all treatments and received a base coating of Vibrance Maxx seed treatment plus Intego.

Table 1. Treatment list for the study of Herbicide Management Strategies for Weed Control in Lentil (Project #AP2001a).

Trt No	Treatment	Timing	Rate	Concentration (g/l)	Rate (g ai/ha)	Abbreviation
1	CONTROL- In crop only-solo	In crop			15	C-Solo
2	Glyphosate	Spring	.67 L /ac	540	893.6	Sp-Gly
3	Glyphosate	Spring	.67 L/ac	540	893.6	Sp-Gly+Ht
	Heat LQ		21.4ml /ac	342	18.1	
	Merge		.2L /ac			
4	Glyphosate	Spring	.67 L/ac	540	893.6	Sp-Gly+Gd
	Goldwing		133ml/ac	433.5	142.4	
5	Edge	Fall	19.6lb/ ac @ Scott		1100	F-Edge/Sp-Gly
	Glyphosate	Spring	.67 L/ac	540	893.6	
6	Edge1	Fall	19.6 lb/ac			F-Edge+Ht/Sp-gly
	Heat LQ		21.4ml /ac	342	18.1	
	Merge	Spring	.2L /ac			
	Glyphosate		.67 L/ac	540	893.6	
7	Focus co-formulated	Fall	113 ml/ac	500	(139.6 – 168.0)	
	*Rate depends on soil texture					F-Foc+Exp/Sp-Gly
	*Use residual rates					
	Express SG		6 g/ac	50%	7.5	
	Glyphosate	Spring	0.67 L/ac	540	893.6	
8	Focus	Fall	113 ml/ac	500	(139.6 – 168.0)	F-Foc/Sp-Gly
	AgSurf		.25L/ 100L			
	Glyphosate	Spring	0.67 L/ac	540	893.6	
9	Focus	Fall	113 ml/ac	500	(139.6 – 168.0)	F-Foc/Sp-Ht+Gly
	Heat LQ	Spring	21.4ml /ac	342	18.1	
	Merge		.2L /ac			
	Glyphosate		0.67 L/ac	540	893.6	
10	Focus	Spring	113 ml/ac	500	(139.6 – 168.0)	Sp-Foc+Gly
	Glyphosate		0.67 L/ac	540	893.6	
11	Valtera EZ	Fall	90 ml/ ac	480	106.7	F-Val/Sp-Gly
	Glyphosate	Spring	.67 L/ac	540	893.6	
12	Valtera EZ	Fall	90 ml/ ac	480	106.7	F-Val/Sp-Gly+Gol
	Goldwing	Spring	133ml/ac	433.5	142.4	

	Glyphosate		.67 L/ac	540	893.6	
13	Fierce	Fall	85 g/ac	76%	159.6	F-Fie/Sp-Gly
	Agral 90		.25%v/v			
	Glyphosate	Spring	.67 L/ac	540	893.6	
14	Fierce	Fall	85 g/ac	76%	159.6	F-Fie/Sp-Gol+Gly
	Agsurf or Agral 90		.25%v/v			
	Goldwing	Spring	133ml/ac	433.5	142.4	
	Glyphosate		.67 L/ac	540	893.6	
15	Heat LQ	Spring	21.4ml /ac	342	18.1	Sp-Ht+Zidua
	Zidua SC		49ml/ac	500	60.5	
	Merge		.2L/ac			
16	Edge1	Fall	19.6lb/ ac @ Scott		1100	F-Edg/Sp-Ht+Zid
	Heat LQ	Spring	21.4ml /ac	342	18.1	
	Zidua SC		49ml/ac	500	60.5	
	Merge		.2L/ac			

[1] Edge applications were harrowed following application.

Table 2. Timing of crop management practices for all four sites.

Crop Management	Saskatoon	Scott	Swift Current	Redvers
Fall herbicide application	28-Oct-19	21-Oct-19	17-Oct-19	21-Oct-19
Pre-plant herbicide application	13-May-20	13-May-20	05-May-20	15-May-20
Seeding	14-May-20	14-May-20	08-May-20	16-May-20
In-crop application	15-Jun-20	15-Jun-20	08-Jun-20	13-Jun-20

Crop and weed assessment

Throughout the growing season, weed control efficacy was assessed by visual ratings taken at 7-14 (early), 21-28 (mid) and 56 (late) days after emergence (DAE). Visual ratings were conducted based on the Canadian Weed Science Society (CWSS) 0-100% scale (Canadian Weed Science Society, 2018), where values greater than 80% indicate acceptable control. Visual ratings were also conducted to evaluate lentil phytotoxicity based on the CWSS scale at 1-10 at 7-14, 21-28, and 56 DAE (Canadian Weed Science Society, 2018). Treated plots were compared to check plots to see if there was any crop damage (chlorosis or stunting) after herbicide applications. Each treatment was assigned a rating from 0-100% with a rating of 0% indicating no injury and 100% indicating complete mortality. Initial damage of up to 10% is considered acceptable. Lentil plant counts in two, 1-m rows at 14 and 21 days after emergence in the front, middle and back of each plot to assess lentil crop population. Harvesting was done by a small plot combine. Lentil seed yields were adjusted to 14% moisture content seeds. Dried lentil samples were then cleaned and weighed to determine final yield.

Statistical analysis

The data were analyzed using ANOVA. Statistical models were constructed using the GLIMMIX procedure in SAS v. 9.4. Crop density data were only available at Scott and at Saskatoon. Crop yield data were available for all four sites. Here the sites were considered a random factor and the treatments were considered as a fixed effect. Due to the absence of site x treatment random interaction, all the results were shown as averages of all four sites. Residuals were initially tested for normality. Crop yield data and crop density data were analyzed with the normal (gaussian) distribution. The availability of phytotoxicity data varied depending on the sites. Saskatoon and Scott had phytotoxicity ratings for all weed species considered. Swift Current only had wild mustard and other weed phytotoxicity data. Phytotoxicity rating data was not available at Redvers due to low weed populations. Since phytotoxicity are proportion data, they are often skewed and bound by 0-1. Therefore, these data were analyzed using beta distribution with log link function in GLIMMIX. Before analyzing the data, they were converted from percentage to decimal proportions and all 0's were converted to 0.001 and all 1's were converted to 0.9999 in order to overcome the exclusion of 0 and 1 from the analysis. Since phytotoxicity data were available only from Saskatoon and Scott (except Swift Current had wild mustard phytotoxicity data) the site was considered a fixed factor (less number to consider as random factor) and the treatments was considered fixed. All the means were compared using LSD at $P < 0.05$.

10. Results:

Climatic conditions

The temperature during the growing period had some slight variations among sites (Table 3). Saskatoon, Swift Current and Redvers were slightly warmer in most of the months compared to Scott. Redvers had slightly warm weather conditions in June- August compared to the other three locations. Precipitation also varied among sites. There was less variability in the rain fall during May while more variation was observed in the other months. Scott received higher rainfall than others in July, while Saskatoon received its highest rainfall in June. The total rainfall in Swift Current and Redvers was lower than Scott and Saskatoon.

Table 3. Mean monthly precipitation and temperature from May to August 2020 for all four sites.

	Site/Month	May	June	July	August	Total
Precipitation (mm)	Scott	48.3	70.2	129.4	25.8	274
	Saskatoon	40	116	27	22.5	205
	Swift Current	36.3	80	62.5	6.5	185
	Redvers	22.85	59.6	47.7	36	166
Temperature (°C)	Scott	10.2	14.6	17.1	16	-
	Saskatoon	11.7	14.9	18.7	17.3	-
	Swift Current	10.9	16.6	18.2	19.5	-
	Redvers	10.5	16.75	19.1	18.5	-

Crop emergence

Crop emergence data were only available at Saskatoon and Scott sites. Crop emergence found to vary among sites and among treatments within sites. Crop mean density was higher at Scott (148 pl m^{-2}) than Saskatoon (48 pl m^{-2}). Crop density also varied among treatments at each site.

Crop Phytotoxicity

Crop phytotoxicity data were only available at Saskatoon and Scott sites. All herbicide treatments found to have very low crop phytotoxicity (0-15%) at Saskatoon and Scott. The control treatment Solo application had the least toxicity at all growth stages at both sites. Treatment 6 (F-Edge+Ht/Sp-gly) and Treatment 12 (F-Val/Sp-Gly+Gol) had slightly higher toxicity (14%) at Saskatoon at 7-14 DAE; however, it was identified to be lower at 14-28 and 56 DAE. At 56 DAE none of the herbicide treatment showed greater than 5% phytotoxicity at both locations, indicating they all can be used effectively in lentils.

Table 4. Crop phytotoxicity percentage data assessed at Saskatoon and Scott 2020.

Treatment no.	Treatments	Saskatoon			Scott		
		7-14 DAE	21-28 DAE	56 DAE	7-14 DAE	21-28 DAE	56 DAE
1	C-Solo	0.64 (0.32)	0.28 (0.13)	0.36 (0.18)	1.26(0.45)	0.80(0.29)	0.79(0.28)
2	Sp-Gly	2.86 (1.00)	0.28 (0.13)	0.36 (0.18)	1.96(0.66)	1.00(0.34)	0.87(0.31)
3	Sp-Gly+Ht	1.56 (0.67)	0.28 (0.13)	0.36 (0.18)	1.59(0.56)	1.05(0.38)	1.14(0.40)
4	Sp-Gly+Gol	10.62 (2.10)	8.61 (0.97)	2.33 (0.71)	3.32(1.06)	3.36(0.85)	2.32(0.67)
5	F-Edge/Sp-Gly	2.86 (1.00)	0.28 (0.13)	0.36 (0.18)	1.96(0.66)	1.03(0.35)	1.02(0.35)
6	F-Edge+Ht/Sp-gly	14.21 (2.42)	12.44 (1.14)	8.71 (1.6)	4.53(1.25)	4.81(1.05)	3.96(0.95)

7	F-Foc+Exp-Sp-Gly	11.75 (2.21)	10.2 (1.04)	5.08 (1.14)	3.00(0.91)	6.43(1.27)	4.79(1.07)
8	F-Foc/Sp-Gly	2.84 (0.99)	0.28 (0.13)	0.36 (0.18)	3.96(1.15)	1.87(0.54)	1.70(0.52)
9	F-Foc/Sp-Ht+Gly	0.65 (0.32)	0.28 (0.13)	0.36 (0.18)	1.58(0.55)	1.49(0.47)	1.56(0.49)
10	Sp-Foc+Gly	0.65 (0.32)	0.28 (0.13)	0.36 (0.18)	1.56(0.54)	1.49(0.47)	1.41(0.46)
11	F-Val+Gly	0.65 (0.32)	0.28 (0.13)	0.36 (0.18)	1.49(0.53)	1.49(0.47)	0.99(0.34)
12	F-Val/Sp-Gly+Gol	14.21 (2.42)	10.2 (1.04)	3.96 (1.02)	8.30(1.84)	6.67(1.29)	3.52(0.89)
13	F-Fie/Sp-Gly	1.6 (0.67)	0.49 (0.19)	0.36 (0.18)	2.36(0.76)	1.69(0.51)	1.55(0.493)
14	F-Fie/Sp-Gol+Gly	10.62 (2.10)	5.22 (0.76)	0.36 (0.18)	7.94(1.78)	6.29(1.25)	1.56(0.49)
15	Sp-Ht+Zidua	2.83 (0.99)	0.28 (0.13)	0.36 (0.18)	3.63(1.09)	1.49(0.47)	1.48(0.47)
16	F-Edge/Sp-Ht+Zid	10.62 (2.10)	0.96 (0.30)	0.36 (0.18)	7.21(1.70)	2.96(0.79)	1.76(0.53)

*Values in parenthesis are standard errors of the mean.

Weed Phytotoxicity:

Wild mustard

Wild mustard phytotoxicity data were only available at Saskatoon, Scott and Swift Current sites. There was a treatment x site interaction for wild mustard at all crop growth stages, indicating treatments had differences in phytotoxicity depending on the site. At Saskatoon, at early stage (7-14 DAE), all treatments showed 80% phytotoxicity (Figure 1a). However, the control treatment (application of Solo) did not show any phytotoxicity on wild mustard. Phytotoxicity was more variable among treatments when assessed at mid and late growth stages (Figure 1b,c). At both mid and late stages, treatment 9 (F-Foc/Sp-Ht+Gly) showed the most phytotoxicity (60%) compared to most other treatments. The treatment 14 (F-Fie/Sp-Gol+Gly) was also found to have similar toxicity to treatment 9 at both stages. At these stages, treatment 2 (Sp-Gly), 5 (F-Edge/Sp-Gly), 11 (F-Val+Gly) and 16 (F-Edg/Sp-Ht+Zid) showed less phytotoxicity than most other treatments. Overall, the residual effects were more prominent in treatments 9 and 14 at Saskatoon.

At Scott, the majority of the treatments showed above 80 % phytotoxicity except for treatment 1 (Solo), 2 (Sp-Gly), 3 (Sp-Gly+Ht), 5 (F-Edge/Sp-Gly), 7 (F-Foc+Exp/Sp-Gly) and 8 (F-Foc/Sp-Gly) showed low to very low efficacy in wild mustard control at all three stages (Figure 2). The treatment 5 (F-Edge/Sp-Gly) was the least effective in controlling wild mustard at Scott assessed at all three stages, followed by treatment 2 (Sp-Gly). Similarly, low phytotoxicity was identified in treatment 2 and 5 at Saskatoon at 14-28 DAE and 56 DAE (Figure 1b and 1c). No effect of Solo application could be due to the use of CL mustard as wild mustard in this experiment. Compared to Saskatoon, all the treatments that have identified better phytotoxicity showed greater residual effects at Scott.

Table 5. ANOVA for the treatments and site on wild mustard, kochia and canola phytotoxicity assessed at Saskatoon and Scott.

	Wild mustard			Kochia			Canola		
	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Trt	<.0001	<.0001	<.0001	<.0001	<.0001	<.0006	<.0001	<.0001	<.0001
Site	0.173	<.0001	<.0001	<.0001	0.6188	<.0001	0.112	<.0001	<.0001
Trt x Site	<.0001	<.0001	<.0001	<.0001	0.0005	<.0001	<.0001	<.0001	<.0001

*Wild mustard phytotoxicity results consist of data from Saskatoon, Scott and Swift Current.

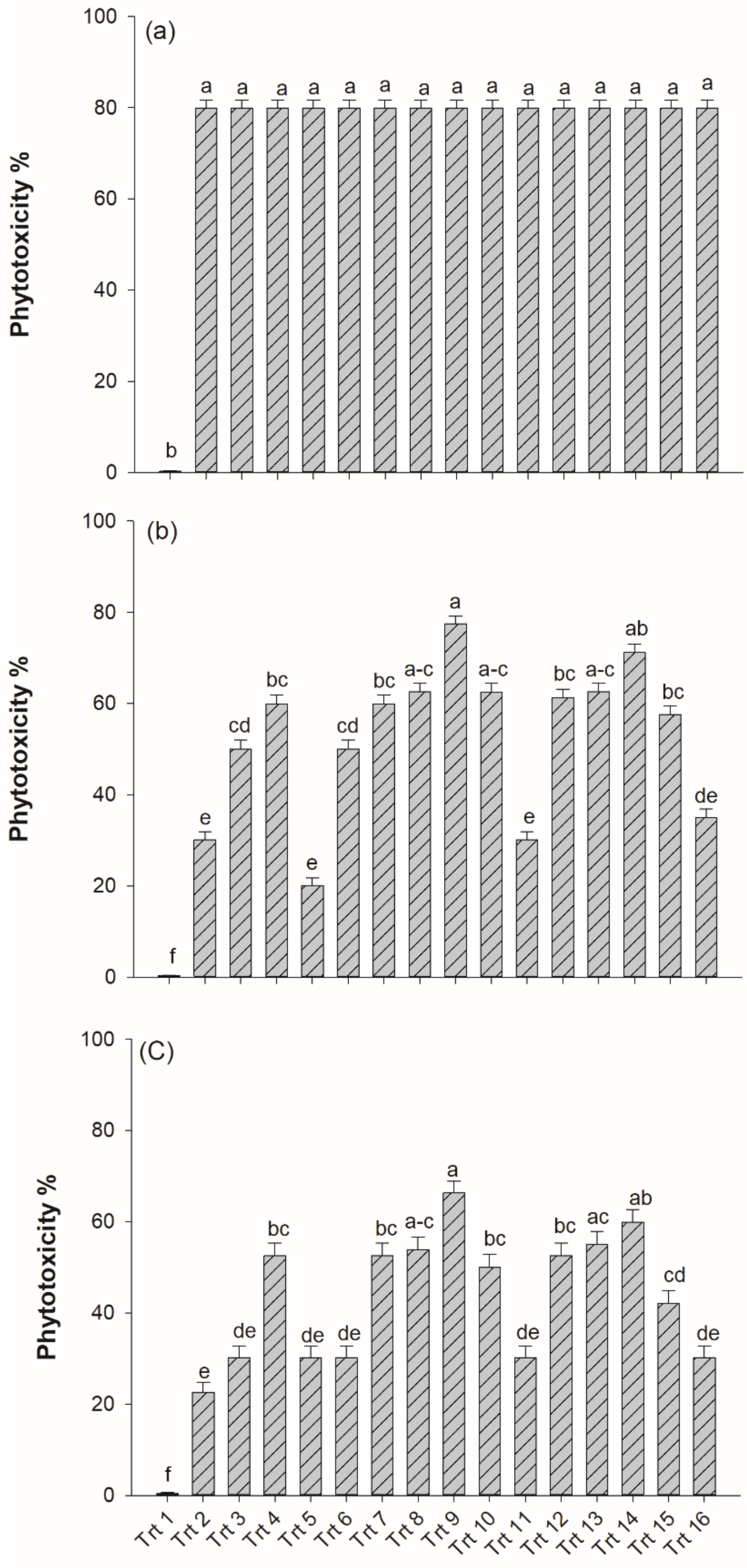

Figure 1. Wild mustard phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), and 56 DAE (c) at Saskatoon 2020.

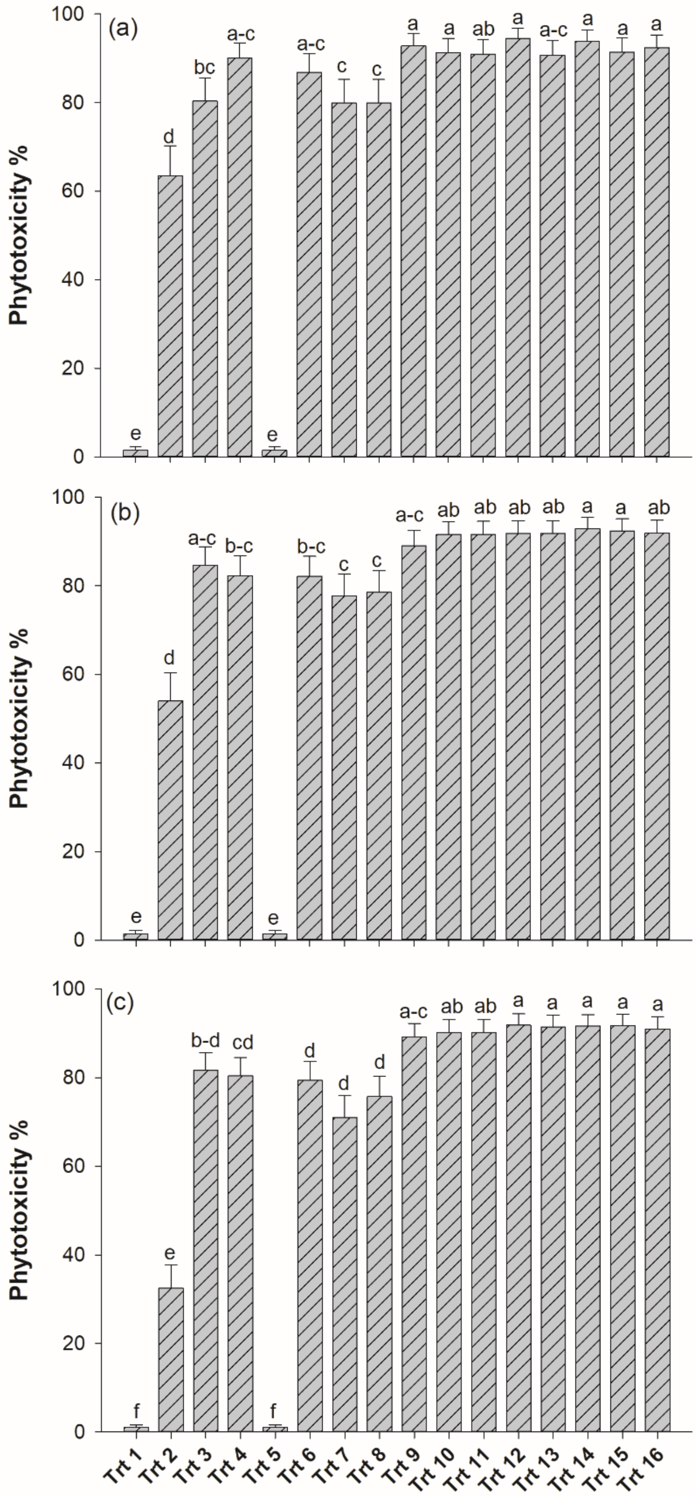

Figure 2. Wild mustard phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), and 56 DAE (c) at Scott 2020.

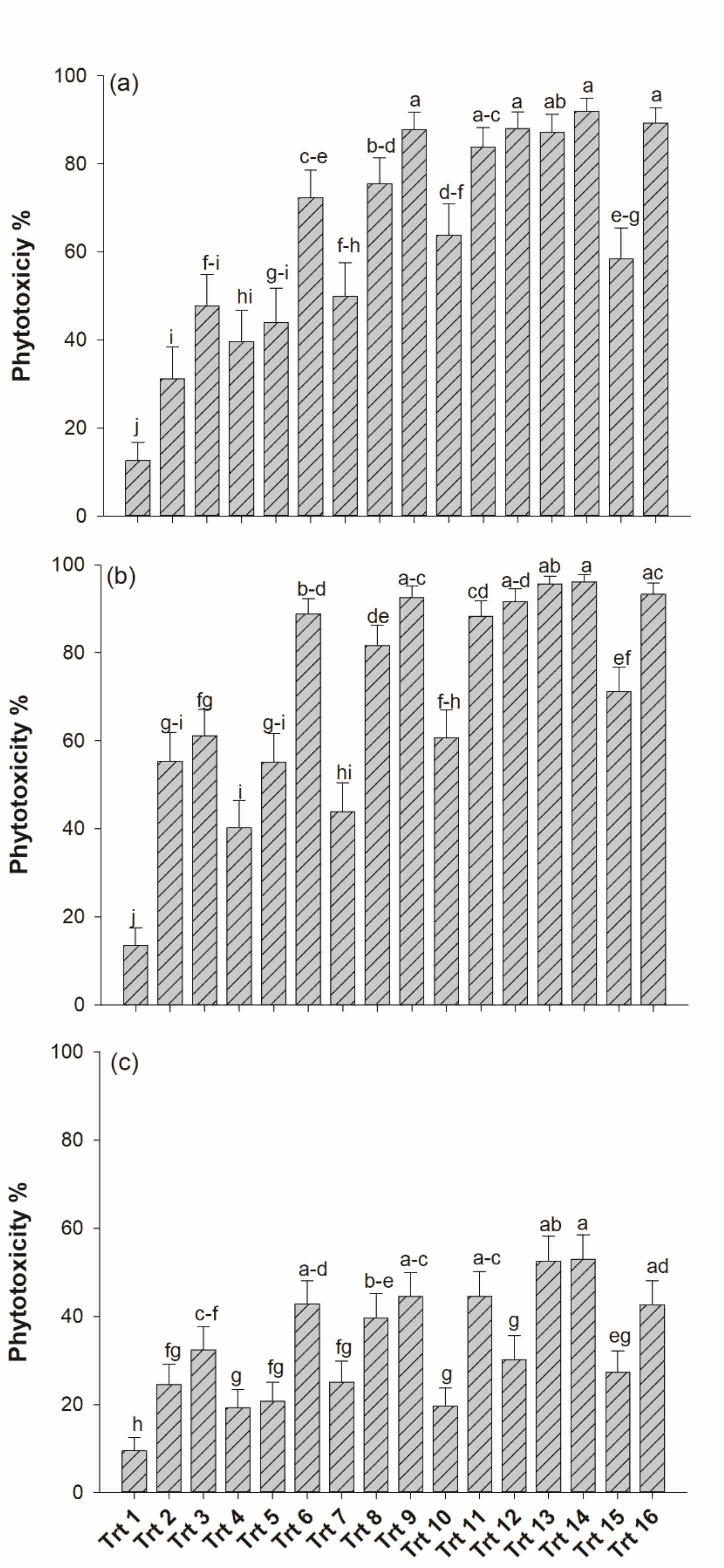

Figure 3. Wild mustard phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), and 56 DAE (c) at Swift Current 2020.

At Swift Current, the treatments 9, 12, 13, 14 and 16 showed more than 80% phytotoxicity at both early and mid-stages (Figure 3). Treatment 6 and Treatment 11 also showed more than 80% at mid-stage. At late-stage, treatment 6, 9, 11, 13, 14 and 16 showed greater phytotoxicity (>40%) than other treatments. Treatments 13 and 14 showed high phytotoxicity at all the three stages, indicating better residual activity. The treatment 1-5, 7, 10 and 15 had low phytotoxicity compared to other treatments at all the three stages.

Kochia control

Kochia phytotoxicity data were only available at Saskatoon and Scott sites. There was a treatment by site interaction for kochia phytotoxicity at all stages (Table 5). Therefore, treatments were compared within sites. At Saskatoon, during the early stage, all treatments except treatment 1 (Solo) and 2 (Sp/Gly) showed above 80 % control of kochia. The herbicide Solo generally has low phytotoxicity on Kochia and it was confirmed in this study (Figure 4a). At mid-stage, only the treatments 12 (F-Val/Sp-Gly+Gol), 13 (F-Fie/Sp-Gly) and 16 (F-Edg/Sp-Ht+Zid) showed above 80% phytotoxicity (Figure 4b). At this stage, treatments 1-4 showed significantly low phytotoxicity than the rest of the treatments. At the late stage, all treatments showed below 80% phytotoxicity (Figure 4c). All treatments except treatments 1, 2, 3 and 5 showed significantly low phytotoxicity. At Scott, at the early stage, treatments 1, 2 and 3 showed the least (<80%) phytotoxicity compared to the other treatments (Figure 5a). During the mid-stage, the phytotoxicity was less than 80% for all treatments except for treatment 3 (Sp-Gly+Ht) and 11 (F-Val+Gly). The treatments 1, 8, 10, 14 and 16 showed significantly low phytotoxicity compared to other treatments (Figure 5b). At the late stage, treatments 1-4 showed the least phytotoxicity (<50%) (Figure 5c).

Canola

Canola phytotoxicity data were only available from Saskatoon and Scott sites. There was a treatment by site interaction for canola phytotoxicity at all stages (Table 5). Therefore, treatments were compared within sites. At Saskatoon, at the early stage, treatment 1 and 2 showed the least phytotoxicity (<80%) (Figure 6a). All other treatments showed greater than 79% phytotoxicity. At the mid-stage, there was a lot of variability in-terms of phytotoxicity among treatments (Figure 6b). Most treatments showed less than 80% phytotoxicity. However, the treatments 4 (Sp-Gly+Gd), 12 (F-Val/Sp-Gly+Gol) and 14 (F-Fie/Sp-Gol+Gly) had greater phytotoxicity (>80%). At the late stage, all treatments showed less than 60% phytotoxicity (Figure 6c). Treatments 4 and 14 showed significantly higher phytotoxicity than most treatments except 3, 11 and 12, which also showed some intermediate-high phytotoxicity compared to the other treatments.

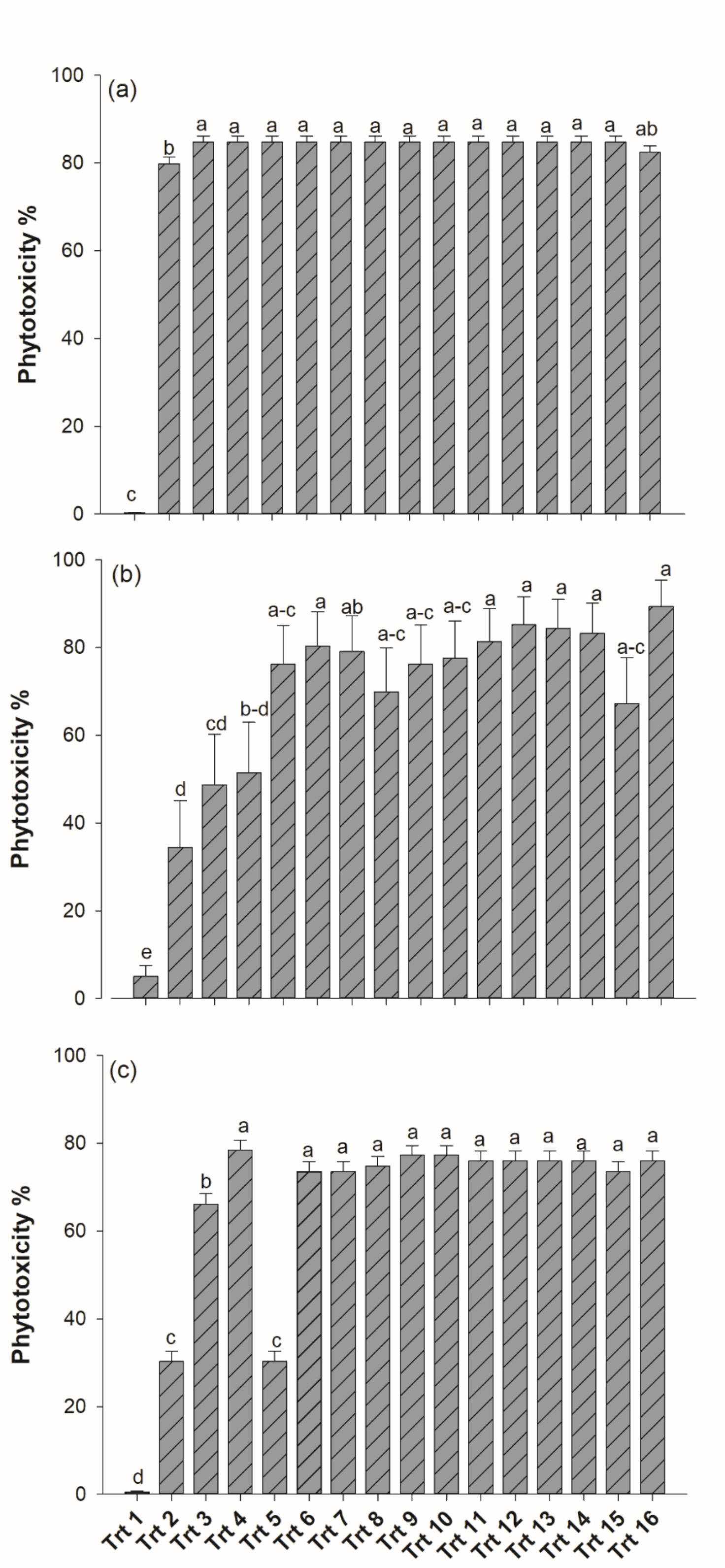

Figure 4. Kochia phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), and 56 DAE (c) at Saskatoon 2020.

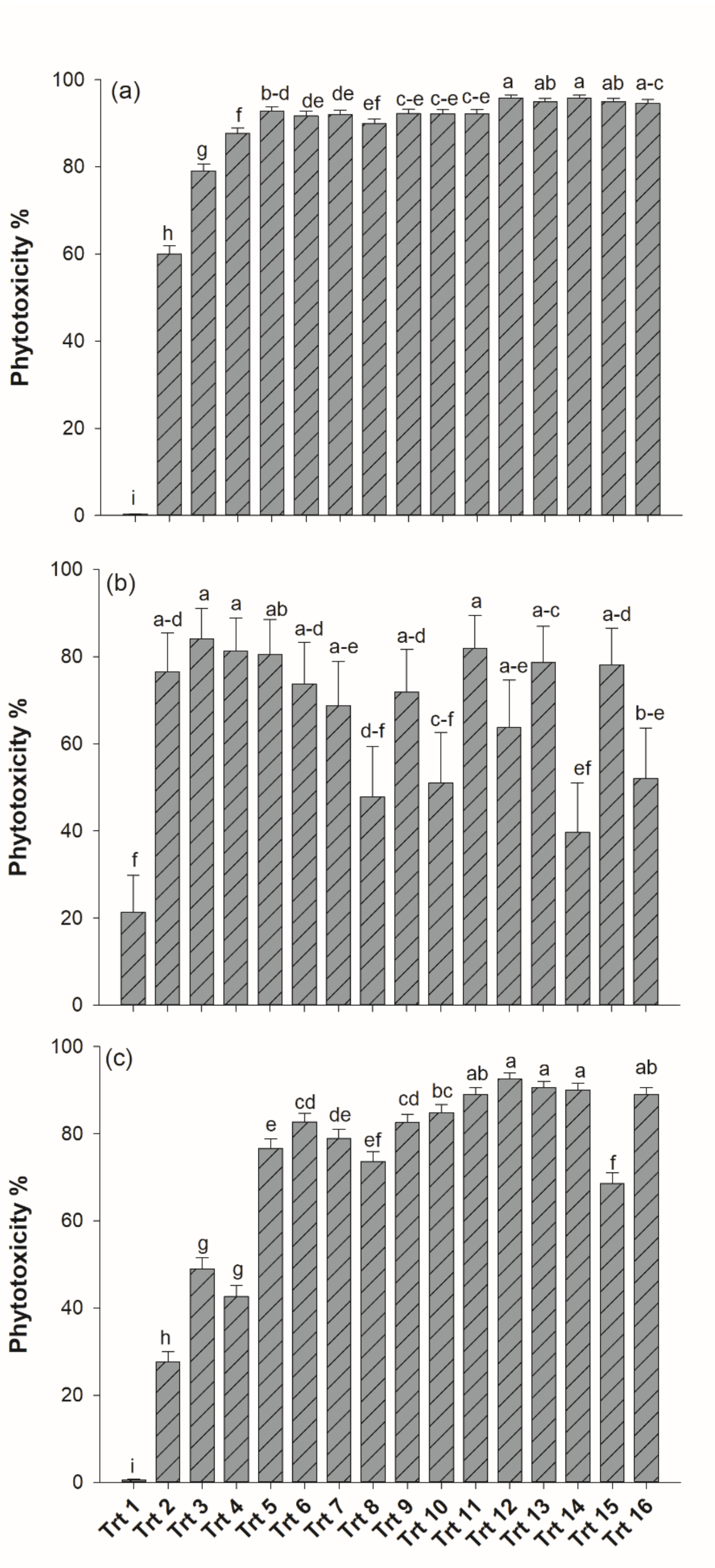

Figure 5. Kochia phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), and 56 DAE (c) at Scott 2020.

At Scott, in all the three stages, treatments showed similar responses (Figure 7). Treatments 1, 2, 5, 7 and 8 had low phytotoxicity (<80%) compared to the other treatments. At all three stages, treatment 1 (Solo), 2 (Sp-Gly) and 5 (F-Edge/Sp-Gly) showed the least phytotoxicity. In all these stages, treatments 9-16 showed similar high phytotoxicity to canola.

Other weed species

Phytotoxicity of other weeds assessed at Saskatoon showed above 80% phytotoxicity at the early stage except for treatments 1 and 2. At mid-stage treatments 1, 2 and 5 showed relatively low phytotoxicity (Figure 8). Treatments 9 and 14 showed significantly higher phytotoxicity compared to most other treatments at all three stages, indicating better weed control. At Scott, all treatments except 1, 2 and 5 showed above 80% phytotoxicity at the early stage (Figure 9a). Treatment 9-16 showed comparatively higher toxicity at both mid and late stages. Treatments 1, 2 and 5 were the least phytotoxic at all three stages. At Swift Current at all the three stages, treatment 1-5, 7, 10 and 15 showed comparatively low phytotoxicity (Figure 10).

Dockage

Dockage percentage varied among sites and treatments. Among the three sites where percentage dockage data was available, Redvers and Scott showed significant differences ($P < 0.05$) among treatments (Figure 11). At Redvers, treatment 4, 8, and 10 had a significantly higher percentage than treatment 11, which had the lowest dockage percentage. At Scott, treatments 1, 3 and 5 had greater dockage than most other treatments. At Swift Current, there were no differences identified among treatments.

Summary

From the results, it was identified that treatments 1 (Solo), 2 (Sp- Gly) and 3 (Sp-Gly+ht) were the least effective in controlling the three species. Solo did not show phytotoxicity on wild mustard as Clearfield tolerant canola was used as wild mustard. Further, it is generally known to have less effect on kochia control. Among all the herbicide treatments, wild mustard showed greater phytotoxicity for treatments 9 (F-Foc/Sp-Ht+Gly) and 14 (F-Fie/Sp-Gol+Gly) consistently at all three sites indicating that those are the best herbicide treatments for wild mustard control. With respect to kochia, herbicide treatments 11 (F-Val+Gly), 13 (F-Fie/Sp-Gly) and 14 (F-Fie/Sp-Gol+Gly) were found to be most consistent in causing phytotoxicity at both sites. Canola was mainly controlled by treatment 11 (F-Val+Gly), 12 (F-Val/Sp-Gly+Gol) and 14 (F-Fie/Sp-Gol+Gly) at both sites. The herbicide treatment 14 (F-Fie/Sp-Gol+Gly) showed greater phytotoxicity on all three weeds at all locations, indicating the most suitable candidate to effectively control all three species. Further, this herbicide combination found to be consistently phytotoxic to other weed species assessed at three sites (Saskatoon, Scott and Swift Current). The treatment 14 contains a fall application of Fierce- (Flumioxizin) + (pyroxasulfone) and spring burndown with Goldwing- (pyraflufen-ethyl + MCPA ester) + Glyphosate.

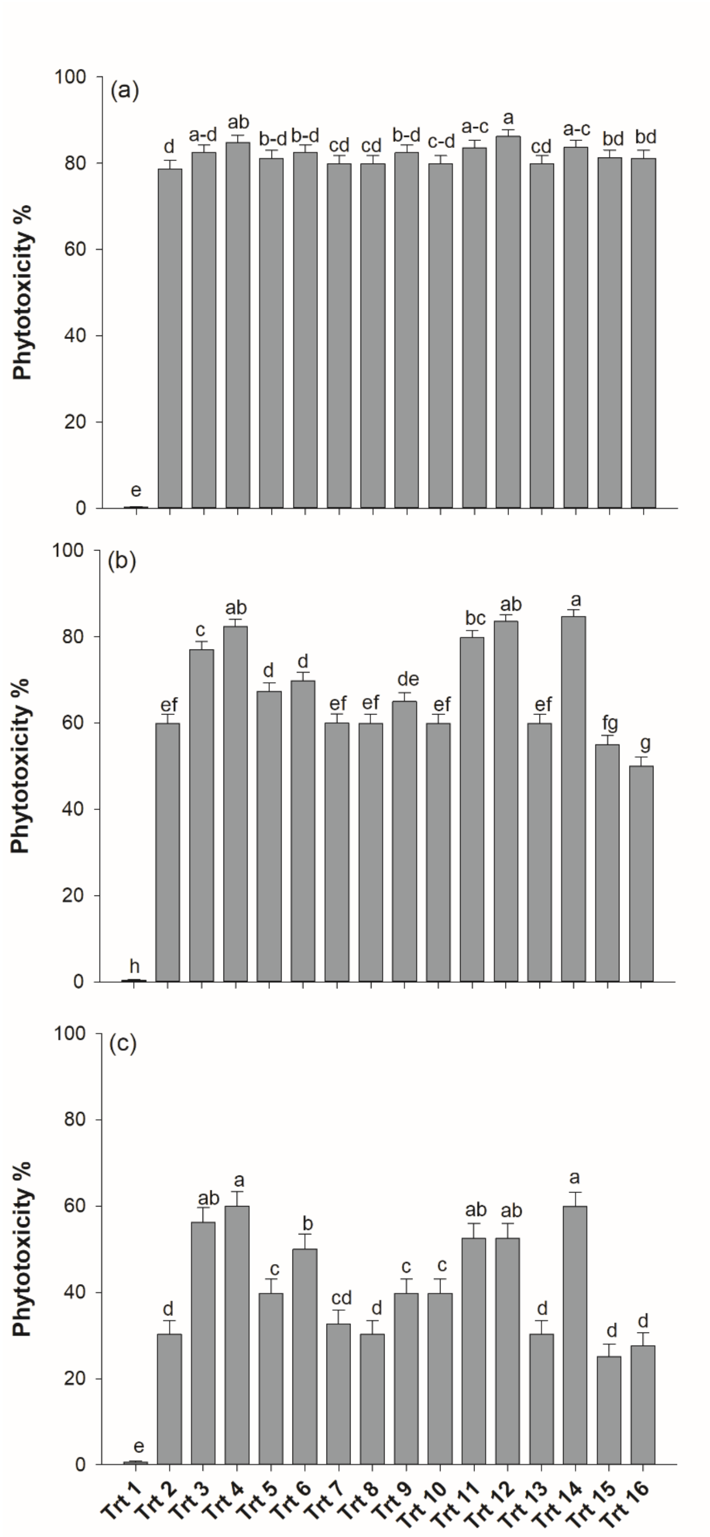

Figure 6. Canola phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), and 56 DAE (c) at Saskatoon 2020.

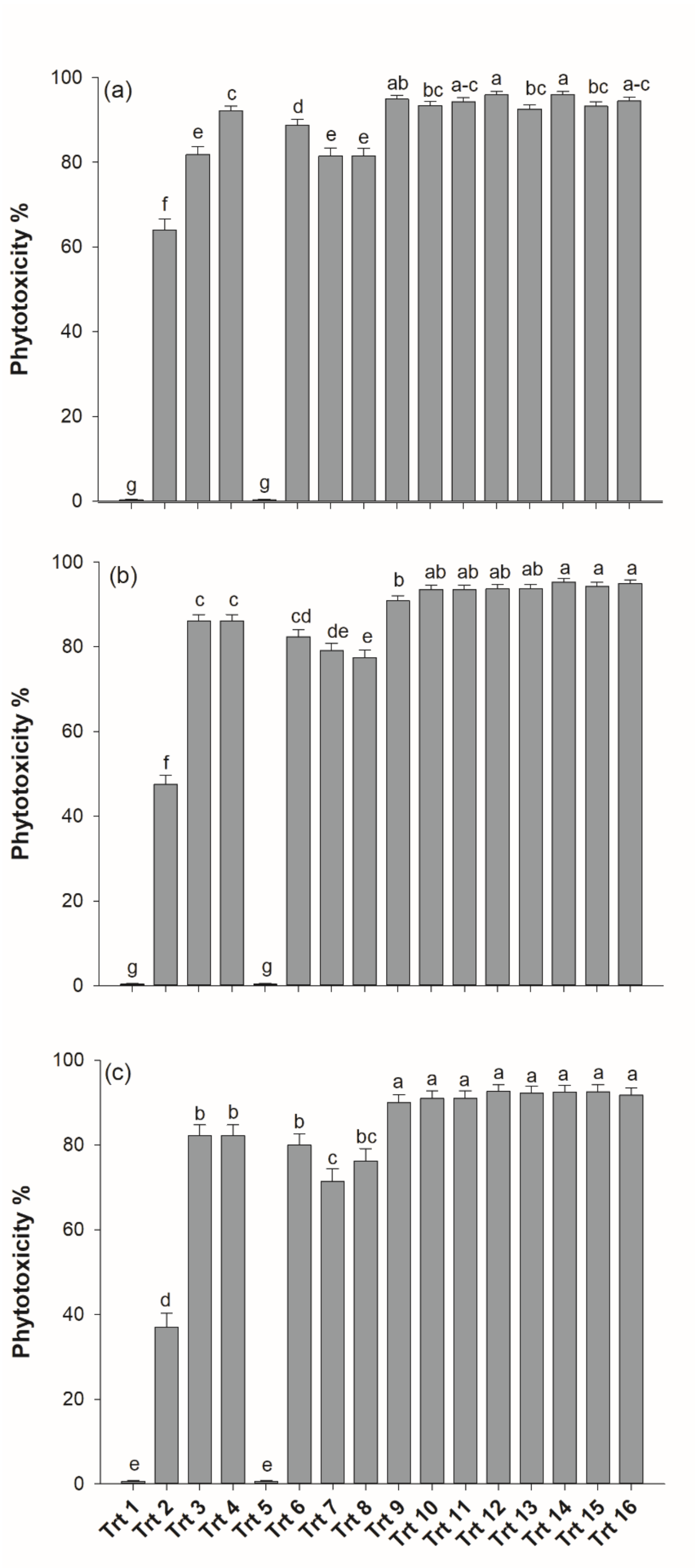

Figure 7. Canola phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), 56 DAE (c) at Scott 2020.

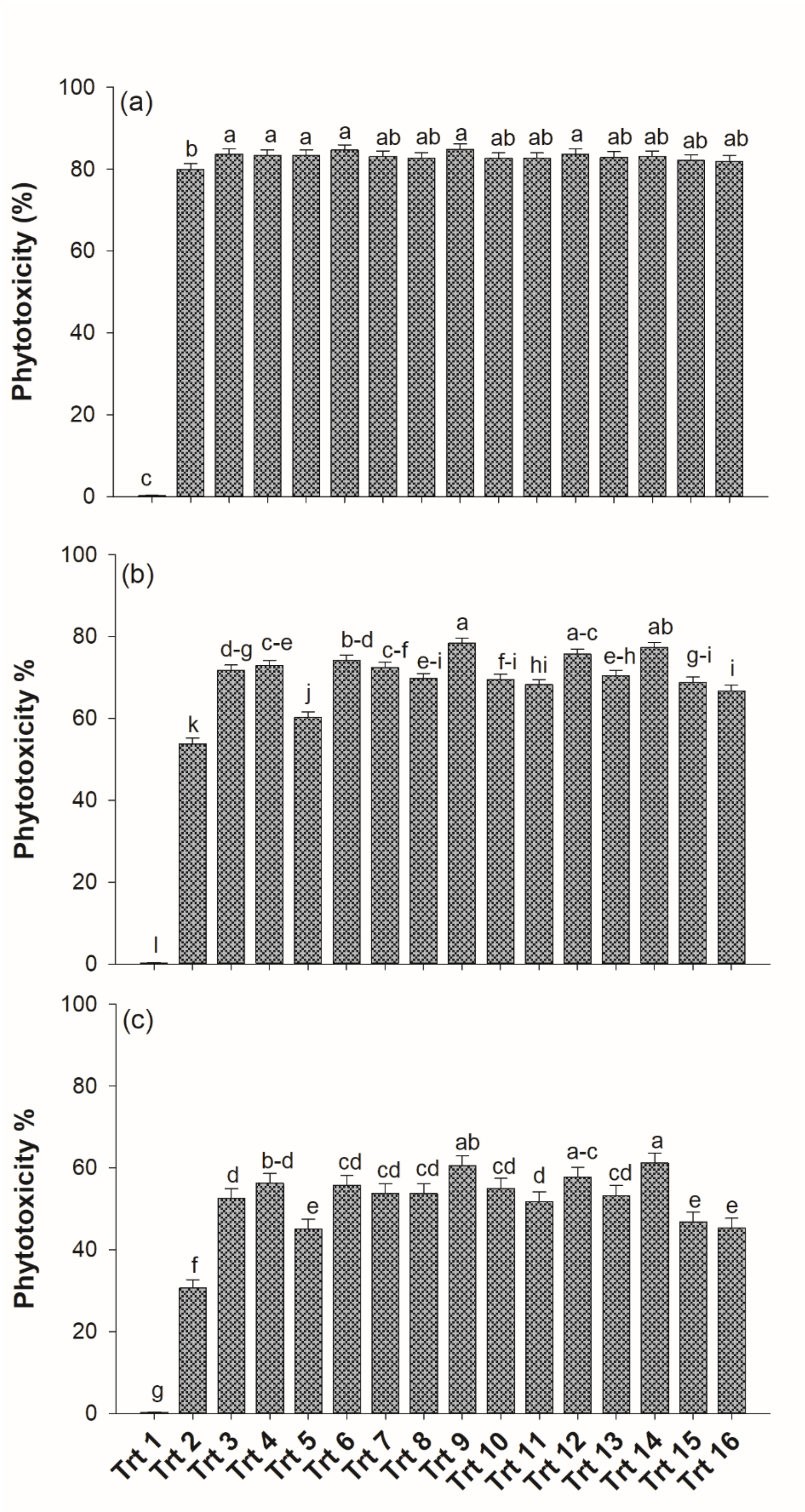

Figure 8. Other weed phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), 56 DAE (c) at Saskatoon 2020.

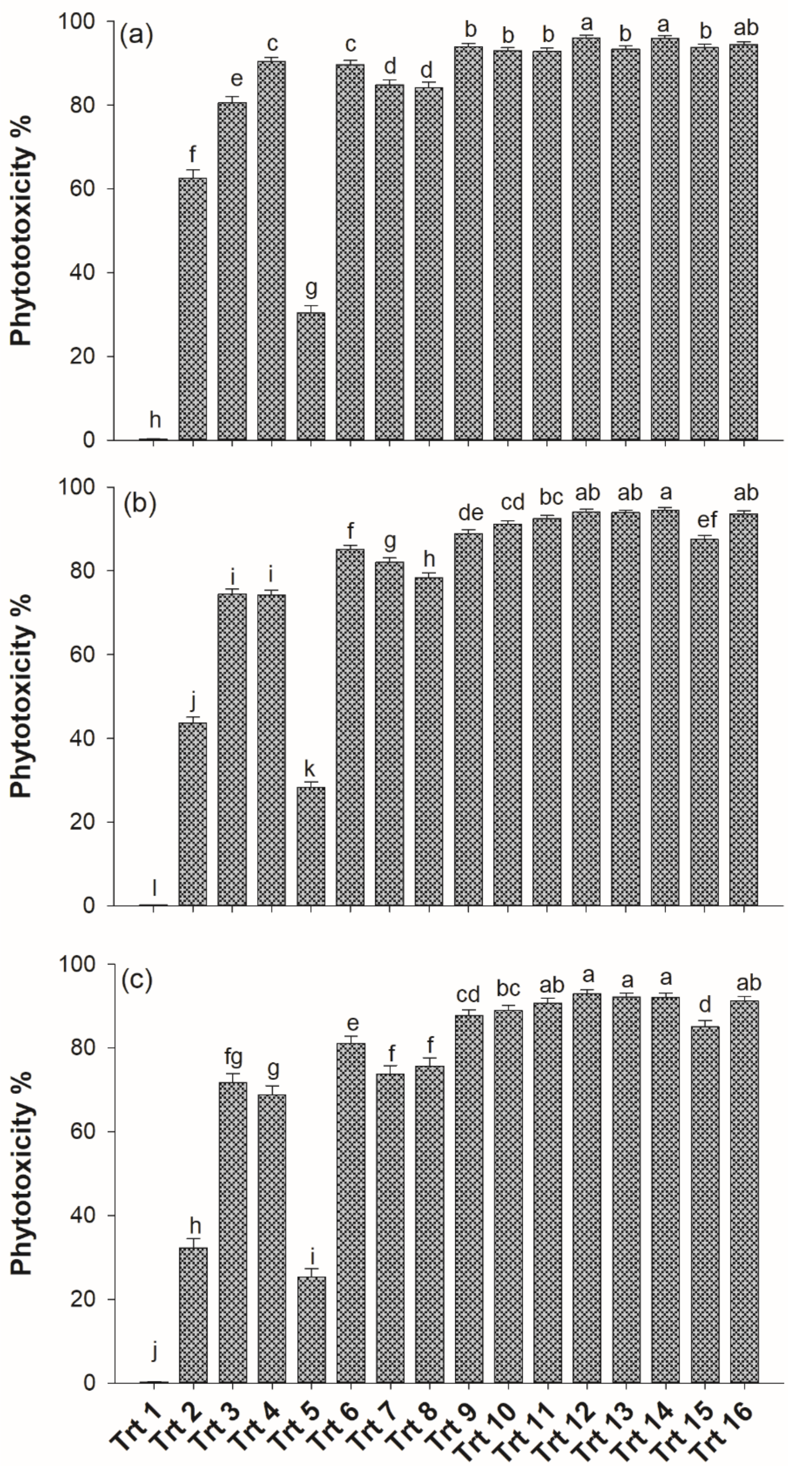

Figure 9. Other weed phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), 56 DAE (c) at Scott 2020.

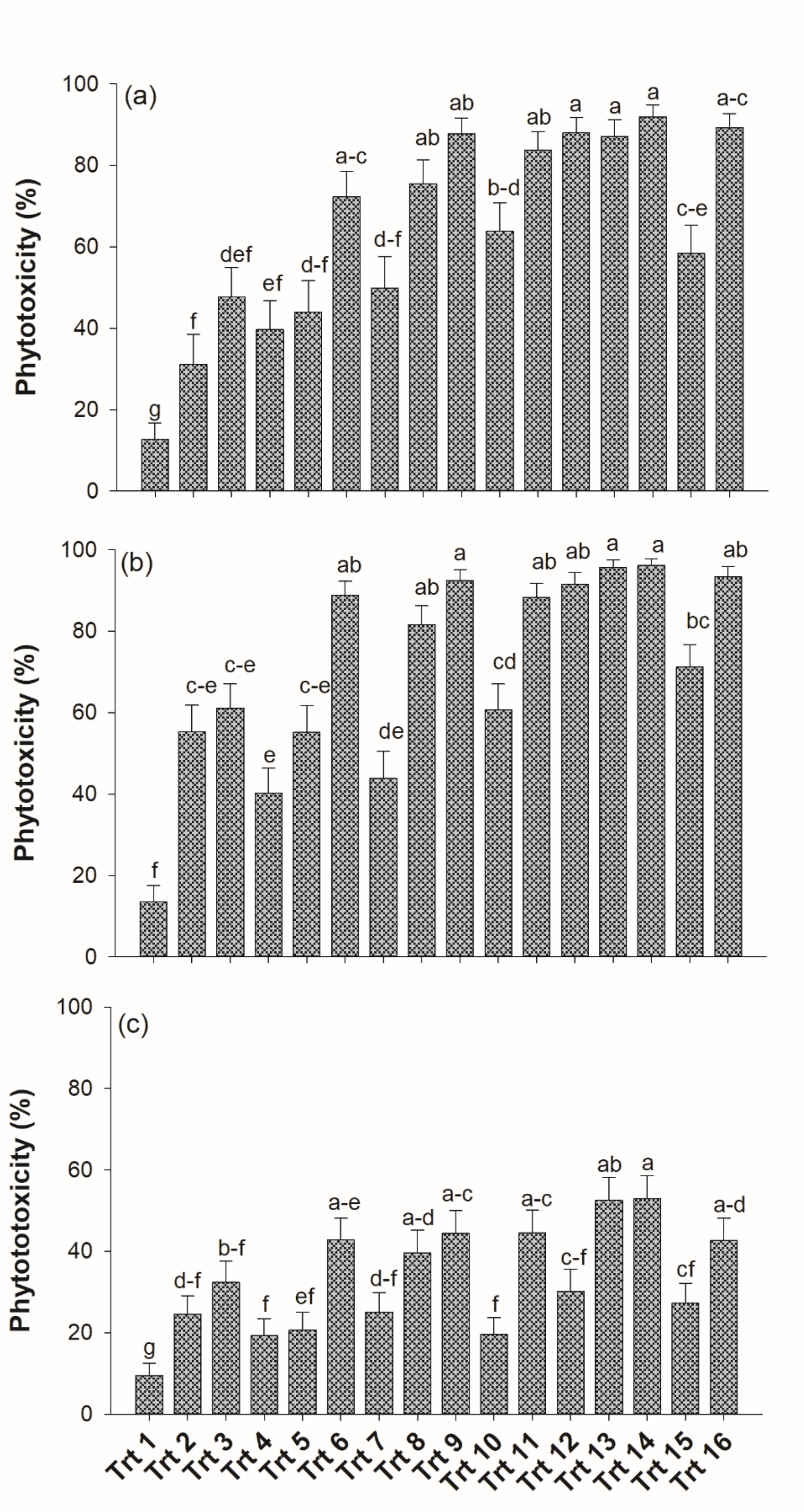

Figure 10. Other weed phytotoxicity assessed at 7-14 DAE (a), 14-28 DAE (b), 56 DAE (c) at Swift Current 2020.

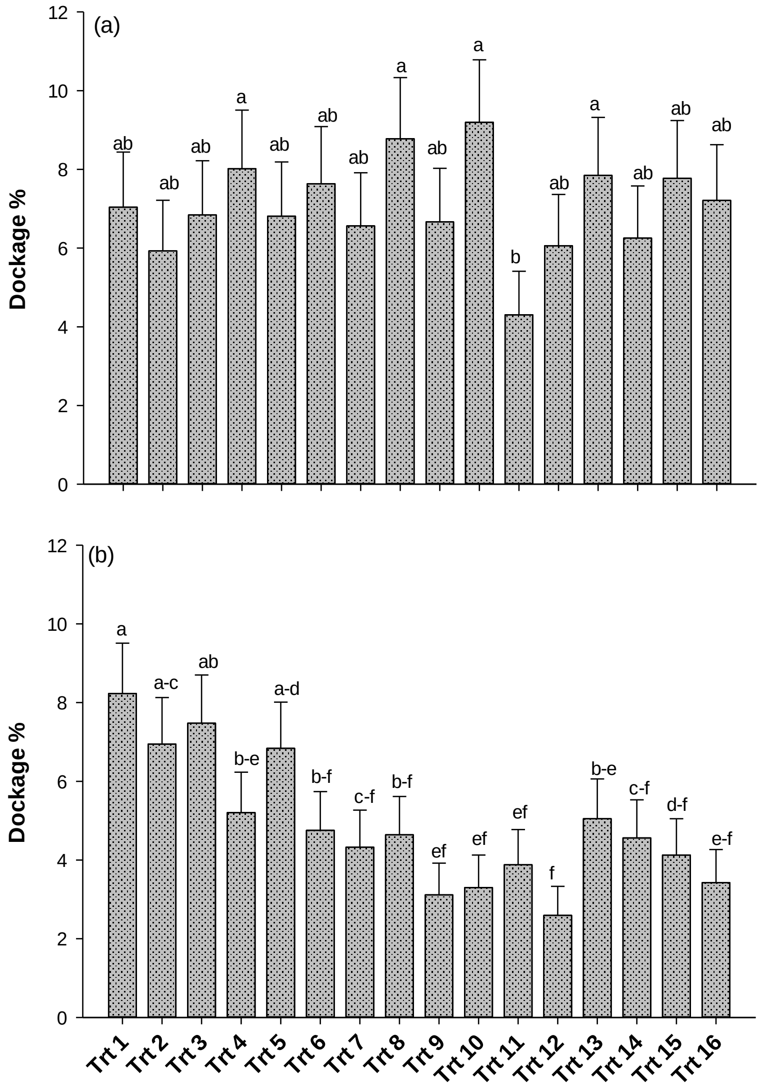

Figure 11. Dockage percentage at (a) Redvers and (b) Scott assessed in 2020.

Crop yields

Crop yields were compared using the data from all four sites (Saskatoon, Scott, Swift Current and Redvers). There was a significant (*P*=0.008) treatment effect identified on crop yields. The treatment 1 (Solo) was found to have the least yield (2590 kg ha^{-1}) followed by treatment 2 and 3, which showed similar low crop yields and was significantly different than most other treatments (Figure 12). All other treatments were found to be similar in crop yields. The highest yielding treatment Sp-Foc+Gly (Treatment 10) had 3024 kg ha, which is 16% greater yield. The most effective herbicide treatment F-Fie/Sp-Gol+Gly (Treatment 14) controlled all the three weeds effectively and had 2902 kg ha$^{-1,}$ which was 12% greater than the control treatment (Treatment 1).

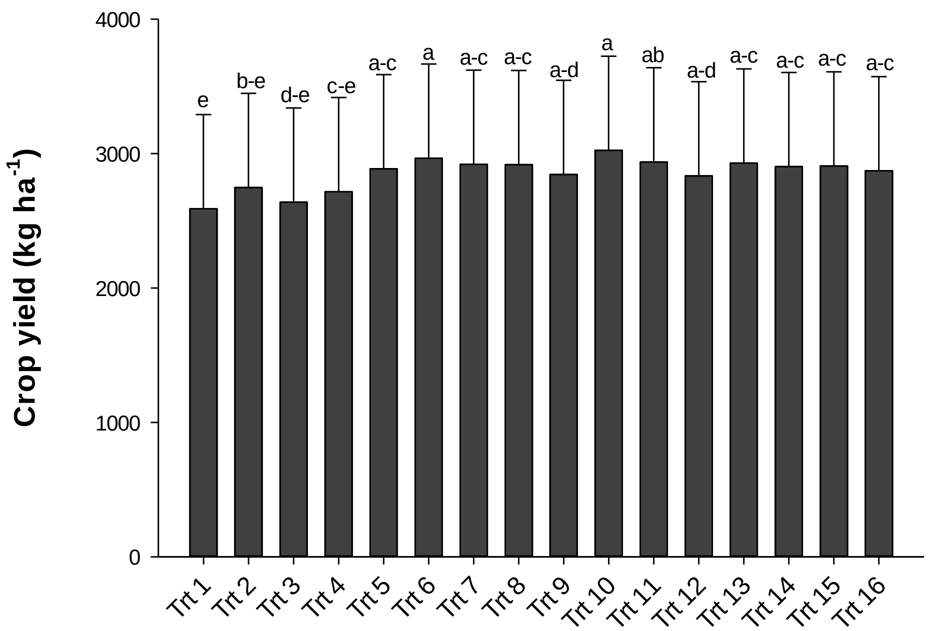

Figure 12. Crop yields at Saskatoon, Scott, Swift Current and Redvers in 2020.

11. Conclusions and Recommendations

The control (Solo) and the spring-applied herbicide treatments Glyphosate, Glyphosate + Heat and Glyphosate + Goldwing were the least effective and inconsistent in controlling the three weed species in this study. Fall application of Focus followed by spring application of Heat + Glyphosate and fall application of Fierce followed by spring application of Goldwing + Glyphosate found to be effective in controlling wild mustard. Herbicide treatments fall application of Valtera followed by spring application of Glyphosate, fall application of Fierce followed by spring application of Glyphosate, and fall application of Fierce followed by spring application of Goldwing + Glyphosate found to be most consistent in causing phytotoxicity in kochia. Canola was mainly controlled by fall application of Valtera followed by spring application of Glyphosate, fall application of Valtera followed by spring application of Glyphosate + Goldwing, and fall application of Fierce followed by spring application of Goldwing + Glyphosate. Fall application of Fierce followed by spring application of Goldwing + Glyphosate found to be the most effective in controlling all three species. This herbicide combination showed greater residual activity as it was effective at all three stages assessed. Since this most effective treatment combination identified to control all the three species have Goldwing (group 4, group 14), Fierce (group 14, group 15), Glyphosate (group 9) it will help to slow down the resistance build-up to any particular MOA. Further, this combination had 12 % greater crop yields compared to the control treatment (Solo application).

Overall, this study confirmed that herbicide application only in the spring was less effective than herbicide application both in the fall and spring, indicating herbicide layering can be an essential strategy to control these species. Further, this approach allows using of multiple modes of action resulting in slowing down the evolution of herbicide resistance. Therefore, based on the results of this study, we can recommend using herbicide layering of fall application followed by spring application of herbicides for better weed management and greater crop yields in lentils.

Extension Activities

A fact sheet will be created and distributed on the WARC website as well as all Agri-ARM and WARC events to ensure the information will be transferred to producers.

Supporting Information

12. Acknowledgements

Financial support was provided by the Saskatchewan Pulse Growers and the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Canadian Agricultural Partnership (CAP) bi-lateral agreement. The Saskatchewan Ministry of Agriculture will be acknowledged in any written or oral presentations which may arise regarding this study. We would also like to acknowledge Herb Schell, and our summer staff Keanna Svendsen-Striga, Jocelyn Leidl, Cortni Millhouse and Breanna Elder for their technical assistance with project development and implementation for the 2020 growing season.

Abstract

13. Abstract/Summary

Increased risk of herbicide-resistant wild mustard and kochia populations in Canada and controlling volunteer canola are becoming major problems in pulses, particularly in lentils. A field study was carried out at four sites (Saskatoon, Scott, Swift Current and Redvers) in Saskatchewan in 2020 to determine alternative herbicide strategies to manage those weeds. Sixteen herbicide combinations with three different timings including fall application and spring pre-plant application, pre-plant application and in-crop application were compared. The

phytotoxicity was assessed at early, mid and late crop stages. The control (Solo) and the spring-applied herbicide treatments Glyphosate, Glyphosate + Heat, and Glyphosate + Goldwing were the least effective and inconsistent in controlling the three weed species in this study. All herbicide combinations with fall application followed by spring application had greater phytotoxicity to all the three weeds and other weeds compared to spring burn-off and in-crop application. Fall application of Fierce followed by spring application of Goldwing + Glyphosate found to be the most effective in controlling all the three species and other weeds. Further, it was able to increase crop yields by 12% compared to Solo application. Overall, this study confirmed that herbicide layering by applying herbicides in the fall and spring could be an essential strategy to control these species.