2018 Research Report

from the

Saskatchewan Pulse Growers

Project Title:
Control of Glyphosate Resistant Canola in Glyphosate Resistant Soybeans
(ADOPT #20170379)

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Project Identification

1. **Project Number:** 20170379
2. **Producer Group Sponsoring the Project:** Saskatchewan Pulse Growers
3. **Project Location(s):** Yorkton, Indian Head, Melfort, and Outlook Saskatchewan.
4. **Project start and end dates (month & year):** April 2018 to February 2019
5. **Project contact person & contact details:**

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Objectives and Rationale

6. **Project Objectives:**

The objectives of this project are:

1. to demonstrate the efficacy of specific pre and post-emergent herbicide options for the control of glyphosate resistant canola volunteers in glyphosate resistant soybeans.
2. to demonstrate improved control of glyphosate resistant canola volunteers by layering pre and post-emergent herbicides
3. to encourage the use of herbicides with differing modes of action to delay the development of herbicide resistance.

7. **Project Rationale:**

Glyphosate resistant (GR) soybeans dominate the market due to convenience and improved weed control over traditional soybeans. Volunteer GR canola is the major weed appearing in GR soybean acres in Saskatchewan. Producers must use herbicides in addition to glyphosate for GR volunteer canola control to minimize soybean yield loss. This is an added cost, but combining herbicides with different modes of action can delay weed resistance. In addition, "layering" of pre and post-emergence herbicides provides the greatest control of GR canola volunteers which emerge early and over an extended period of time. The herbicides in this demonstration are registered in Saskatchewan to control volunteer canola in soybean crops. This study will demonstrate the efficacy of various pre- and post-emergence herbicides alone and in combination.

Methodology and Results

8. **Methodology:**

Trials were located on land that has had a history of glyphosate resistant canola within the last two years and were established as a factorial design with 4 replicates. Plot size varied at

each location based on equipment. The first factor compared an in-crop application of glyphosate alone against glyphosate + Viper ADV. The second factor contrasted pre-seed applications of glyphosate alone and glyphosate tank mixed with either Blackhawk, Authority Charge, Express SG or Heat LQ. Table 1 lists the treatments established. Greater detail regarding herbicide rates are listed below the table.

Every treatment consisted of a pre-seed and post-emergence (in-crop) herbicide application. Treatment 1 consists of glyphosate applied pre and post-emergence. This is the "check" as glyphosate resistant canola will not be controlled by this treatment. Treatment 2 evaluates the addition of Viper ADV post-emergence. This treatment does not benefit from any pre-seed control of the volunteer canola. Treatments 3, 4, 5 and 6 consist of pre-seed applications of Blackhawk, Authority Charge, Express SG and Heat LQ, respectively tank mixed with glyphosate. All of these treatments only have glyphosate applied in-crop so that the control of glyphosate resistant canola volunteers by the pre-seed herbicides can be assessed. Treatments 7, 8, 9 and 10 also consist of pre-seed applications of Blackhawk, Authority Charge, Express SG and Heat LQ, respectively. However, unlike treatments 3 to 6, Viper ADV has been added as an in-crop herbicide. These last four treatments are layering pre-seed and post-emergence herbicides and should provide the best control of glyphosate resistant canola volunteers.

Table 1. Treatment List of Control of Glyphosate Resistant Canola in Glyphosate Resistant Soybean

Treatment	Control of GR Volunteer Canola	Post-emergence (in-crop)	Pre-seed Herbicide
1	No control	Glyphosate only	Glyphosate only
2	In-crop control only	Glyphosate + Viper ADV	Glyphosate only
3	Early control	Glyphosate only	Glyphosate + Blackhawk
4	Early control	Glyphosate only	Glyphosate + Authority Charge
5	Early control	Glyphosate only	Glyphosate + Express SG
6	Early control	Glyphosate only	Glyphosate + Heat LQ
7	Early + in-crop control	Glyphosate + Viper ADV	Glyphosate + Blackhawk
8	Early + in-crop control	Glyphosate + Viper ADV	Glyphosate + Authority Charge
9	Early + in-crop control	Glyphosate + Viper ADV	Glyphosate + Express SG
10	Early + in-crop control	Glyphosate + Viper ADV	Glyphosate + Heat LQ

Detailed Treatment List

1. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)

2. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Viper ADV****-0.4 l/ac* (imazamox/bentazon)
   - ***BASF 28% UAN****-0.81 l/ac*

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)

3. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***BlackHawk****-0.3 l/ac (2,4-D ester + pyraflufen-ethyl)*

4. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Authority Charge***
     i. ***Aim****-18.75 ml/ac* (carfentrazone)
     ii. ***Authority****-118 ml/ac* (sulfentrazone)

5. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Express SG****-4 g/ac* (tribenuron)

6. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Heat LQ****-21.4 ml/ac* (saflufenacil)

7. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Viper ADV****-0.4 l/ac* (imazamox/bentazon)
   - ***BASF 28% UAN****-0.81 l/ac*

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***BlackHawk****-0.3 l/ac (2,4-D ester + pyraflufen-ethyl)*

8. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Viper ADV****-0.4 l/ac* (imazamox/bentazon)
   - ***BASF 28% UAN****-0.81 l/ac*

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Authority Charge***
     i. ***Aim****-18.75 ml/ac* (carfentrazone)
     ii. ***Authority****-118 ml/ac* (sulfentrazone)

9. Post-emergence:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Viper ADV****-0.4 l/ac* (imazamox/bentazon)
   - ***BASF 28% UAN****-0.81 l/ac*

   Pre-seed:
   - ***Roundup transorb****-0.67 l/ac* (glyphosate)
   - ***Express SG****-4 g/ac* (tribenuron)

10. Post-emergence:
    - ***Roundup transorb****-0.67 l/ac* (glyphosate)
    - ***Viper ADV****-0.4 l/ac* (imazamox/bentazon)
    - ***BASF 28% UAN****-0.81 l/ac*

    Pre-seed:
    - ***Roundup transorb****-0.67 l/ac* (glyphosate)
    - ***Heat LQ****-21.4 ml/ac* (saflufenacil)

Table 2 lists the dates various operations occurred at each site.

Table 2. Dates of operations in 2018 for the Control of Glyphosate Resistant Canola in Glyphosate Resistant Soybeans

	----------Date----------			
Activity	**Indian Head**	**Melfort**	**Outlook**	**Yorkton**
Broadcasted canola	n/a		May 18	n/a
Pre-seed Herbicide Application	May 15	May 23	May 24 glyphosate & May 29 (other herbicides)	May 20
Seeding	May 14	May 28	May 29	May 22
Emergence Counts		June 19	June 21	
Control of volunteer canola 14 days after seeding	n/a	June 11	June 12	June 6
In-crop Fungicide Application	n/a	July 27 (Priaxor)		
In-crop Herbicide Application	June 15	July 6	July 5	June 12
Control of volunteer canola 14 days after post emergence application	n/a	June 20	July 19	June 25
Control of volunteer canola 21 days after post emergence application	July 6	July 27	July 26	July 3
Control of volunteer canola 56 days after post emergence application	Aug 10	Aug 31	Aug 31	Aug 7
Harvest	Sept 11	Oct 19	Oct 5	

9. Results:

Growing Season Weather

Mean monthly temperatures and precipitation amounts for Yorkton, Melfort, Outlook, and Indian Head are listed in Table 3. Seasonal temperatures were above average at all locations. Seasonal precipitation was only 61, 87, 42 and 72 percent of the 30 year average for Indian Head, Melfort, Outlook and Yorkton, respectively. Low precipitation at Outlook was not an issue as the site was irrigated.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) normals for the 2018 growing seasons at Indian Head, Melfort, Outlook and Yorkton in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		----------*Mean Temperature (°C)* ----------				
Indian Head	2018	13.9	16.5	15.4	17.6	15.8
	Long-term	***10.8***	***15.8***	***18.2***	***17.4***	***15.6***
Melfort	2018	13.9	16.8	17.5	15.8	16.0
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
Outlook	2018	14.8	17.4	18.5	17.5	17.1
	Long-term	***11.5***	***16.1***	***18.9***	***18.0***	***16.1***
Yorkton	2018	13.9	17.6	18.3	18.1	17.0
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
		---------- *Precipitation (mm)* ----------				
Indian Head	2018	23.7	90	30.4	3.9	148
	Long-term	***49***	***77.4***	***63.8***	***51.2***	***241.4***
Melfort	2018	38.5	46.6	69.5	43.2	196.8
	Long-term	***42.9***	***54.3***	***76.7***	***52.4***	***226.3***
Outlook	2018	24.9	12.9	35.2	12.6	85.6
	Long-term	***42.6***	***63.9***	***56.1***	***42.8***	***205.4***
Yorkton	2018	0.8	120.1	53.8	21.1	196.1
	Long-term	***51***	***80***	***78***	***62***	***272***

Tables 4 to 15 showing the complete analysis for the study can be found in the Appendices.

Trials were well established with soybean emergence averaging 54.5, 54.5, 58.8 and 51.7 plants/m^2 at Yorkton, Melfort, Indian Head and Outlook, respectively. A heavy population of volunteer glyphosate resistant (GR) canola was present at Outlook and Yorkton. At Melfort there was a mixture of glyphosate and liberty canola volunteers, but the liberty volunteers were not a problem as they were controlled in every treatment by glyphosate. At Indian Head there were very few canola volunteers. Ratings for the control of volunteer canola were taken 14 days after seeding, and 14, 21 and 56 days after post-emergent herbicide. The discussion below focuses on ratings taken 14 days after seeding and 56 days after post-emergent herbicide. Ratings from 14 and 21 days after post-emergent herbicide have been omitted from the report as the 56 day rating provides all the information needed for comparison.

When rated 14 days after seeding, the pre-seed herbicides Blackhawk, Authority Charge, Express SG and Heat LQ provided significant and substantial control of volunteer canola at Outlook (Tables 4 and 5, Figure 1). Pre-seed control was much lower at Melfort and Yorkton as the main flush of volunteer canola occurred after pre-seed herbicides were applied. Ratings were not taken at this time from Indian Head because volunteers were not present at this time.

When rated 56 days after post-emergent herbicides were applied, the control of canola volunteers by pre-seed herbicide tank mixes was still significant at Outlook (Tables 7, 8 Figure 2). In addition, pre-seed herbicide tank mixes significantly reduced canola dockage from 42.1% down to 13.6-20.6% (Table 10, 11 and Figure 3) and significantly increased soybean yield from 1480 kg/ha to 2184-2644 kg/ha (Table 14 and Figure 4) depending on herbicide tank mixed with glyphosate. Yield increases associated with the application of Blackhawk or Authority Charge were significantly higher than those of Express SG or Heat LQ. At Yorkton, pre-seed tank mixes were still only providing modest control of volunteers by the 56 day rating and no control could be detected at Melfort (Table 8 and Figure 2). As a result, pre-seed tank mixes did not significantly reduce canola dockage (Table 11 and Figure 3) or increase soybean yield (Table 14 and Figure 4) at either site. Results were somewhat similar at Indian Head, but percent control ratings at 56 days were based off plants counts and not visual comparisons, as there were still very few volunteers by this time. Like Yorkton and Melfort, no significant differences in control of volunteers or soybean yield resulted from the application of a pre-seed tank mix at Indian Head with the exception of Heat LQ. Heat LQ provided significantly less control than glyphosate alone (Table 8 and Figure 2) which in turn resulted in significantly less soybean yield (Table 14 and Figure 4). The reason for this is unclear. Overall, pre-seed herbicides controlled volunteer canola and increased soybean yield at Outlook, but had little affect at the other locations.

Figure 1. Main Effects of Pre-seed Herbicide on Control of Volunteer Glyphosate Resistant Canola 14 days after Seeding

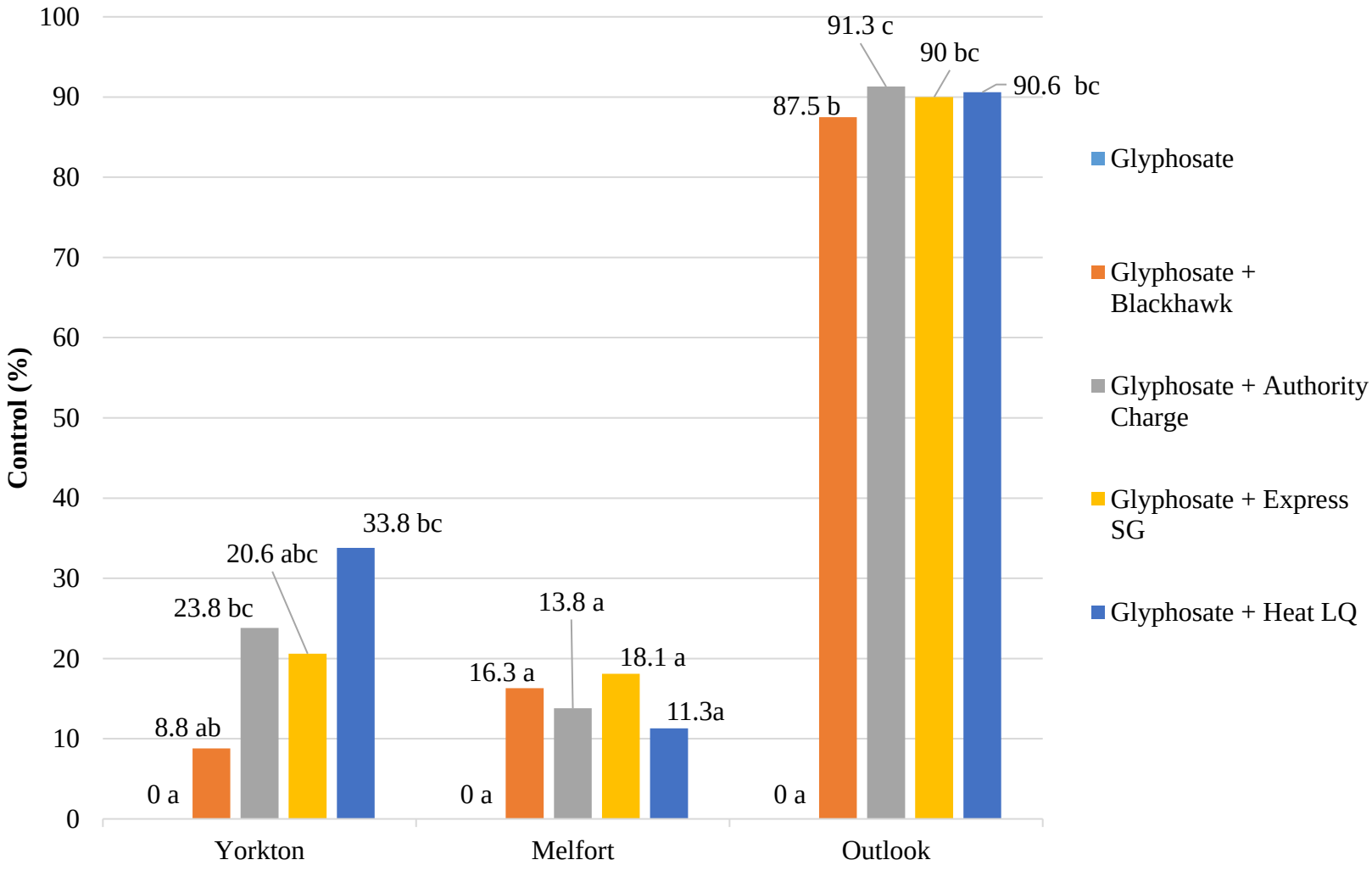


Figure 2. Main Effects of Pre-seed Herbicide on Control of Volunteer Glyphosate Resistant Canola 56 days after Post-Emergent Herbicide

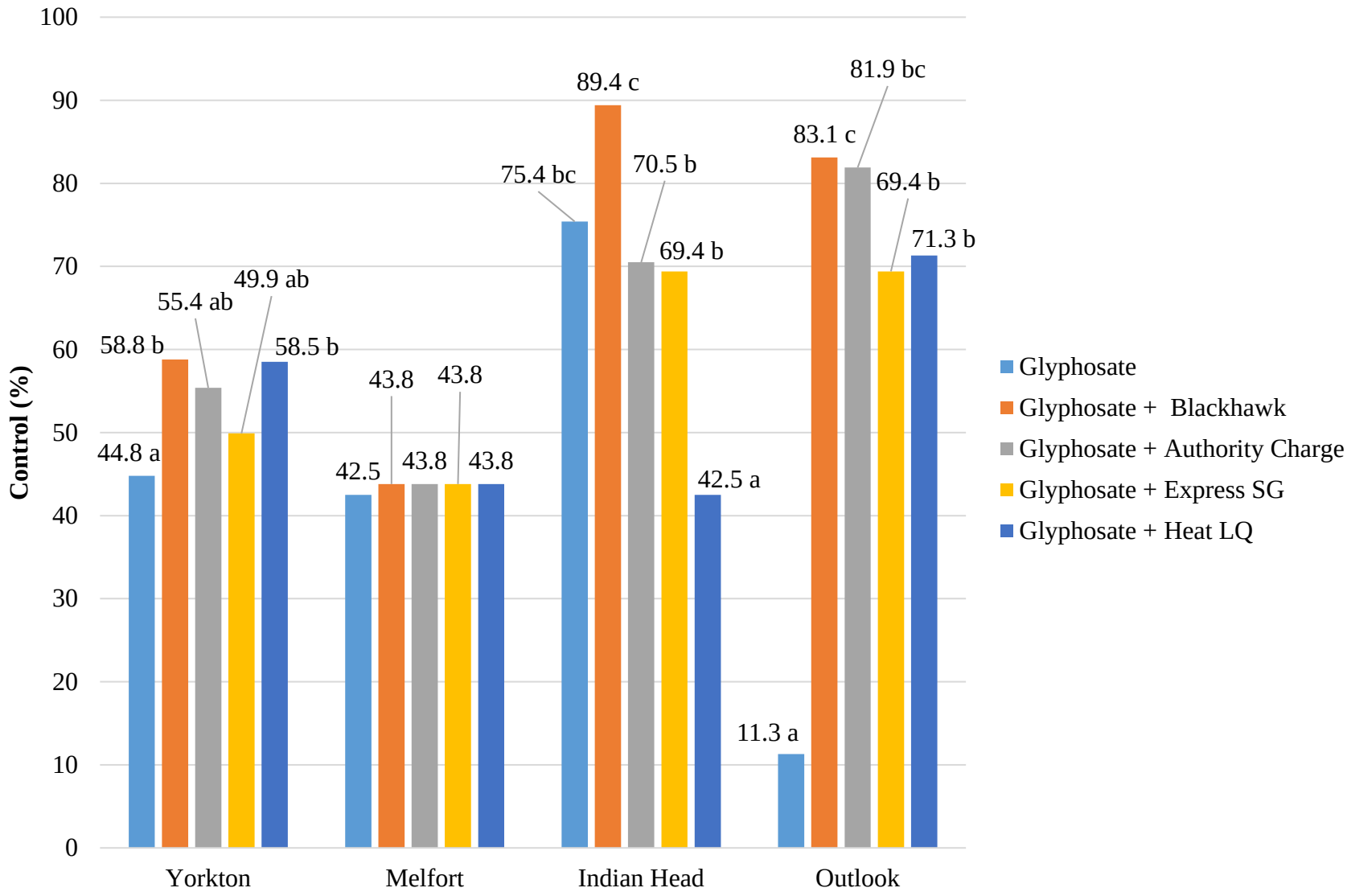


Figure 3. Main Effects of Pre-seed Herbicide Control on Soybean Dockage (%)

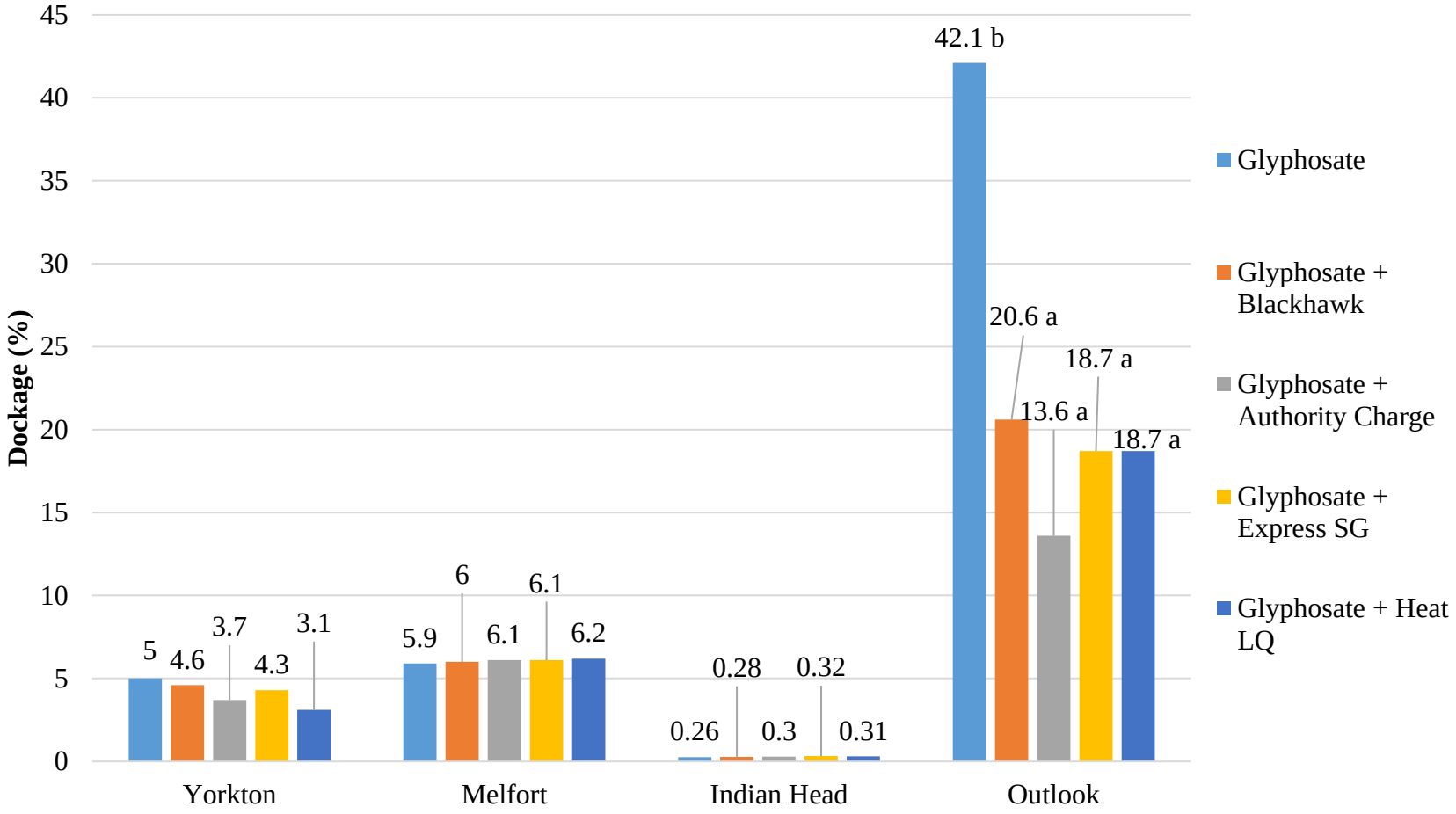
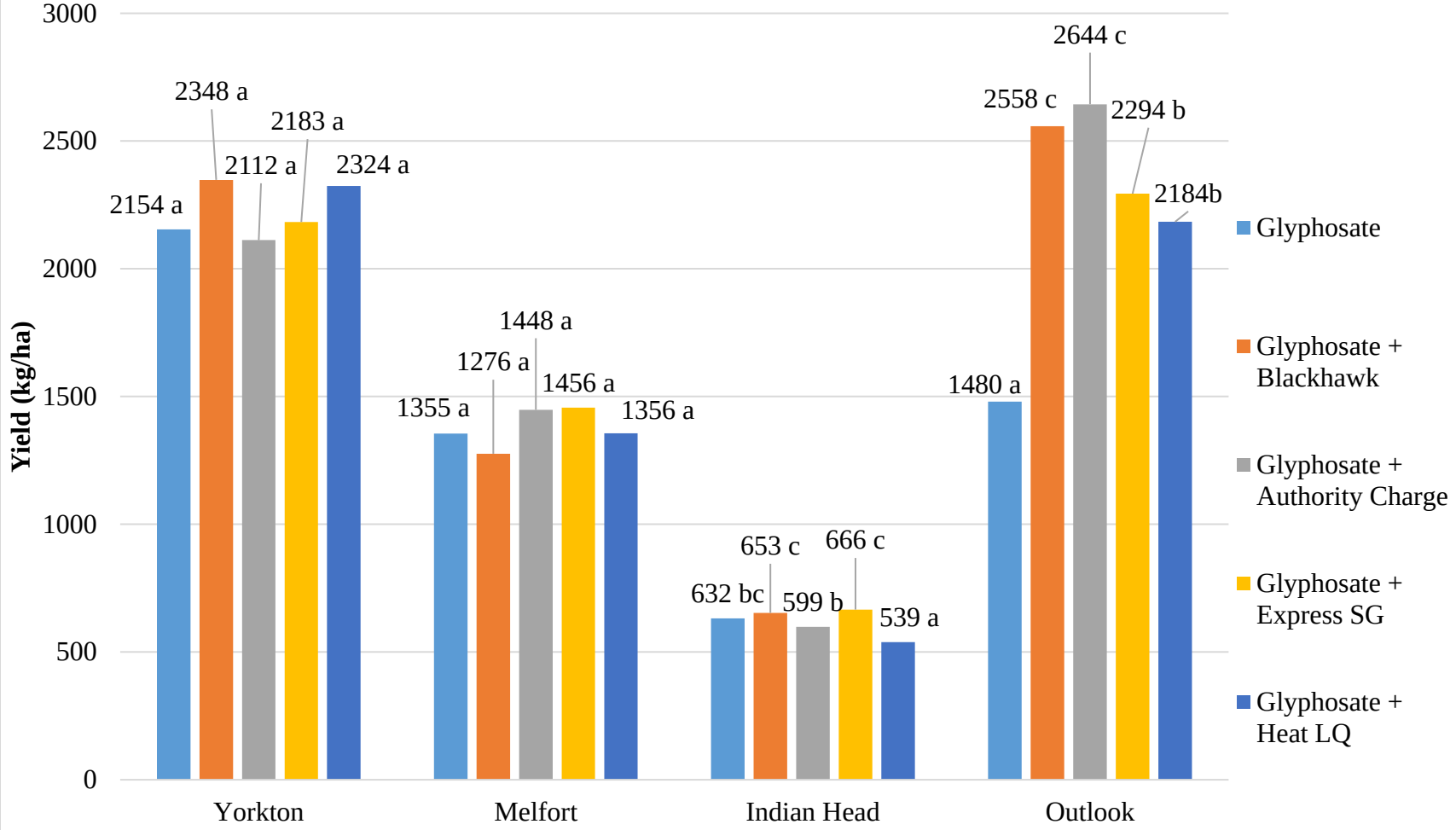


Figure 4. Main Effects of Pre-seed Herbicide Control on Soybean Yield (kg/ha)



An in-crop application of Viper ADV significantly increased the control of volunteer canola (Tables 7 and 8, Figure 5) at all locations and decreased canola dockage at all sites excepting Indian Head (Tables 10 and 11, Figure 6). Dockage was not reduced at Indian Head as there was little volunteer canola present at that site. When averaged across pre-seed herbicide, the in-crop application of Viper ADV significantly increased soybean yield by 28 and 23% at Yorkton and Outlook, respectively (Table 14 and Figure 7). Viper ADV did not increase yields at Melfort or Indian Head. The lack of a yield response was not surprising for Indian Head as there were few canola volunteers. However, a yield response was expected at Melfort as Viper ADV provided excellent control of volunteers.

The benefit of layering pre-seed and in-crop herbicides for the control of volunteer GR canola could not be demonstrated at Yorkton, Melfort or Indian Head. Viper ADV was very efficacious at these locations, providing over 85% control (Table 9). Moreover, Viper ADV alone reduced canola dockage from 8.8% down to 1.2% at Yorkton and from 11.2% down to 0.6% at Melfort (Table 12). Layering with a pre-seed herbicide tank mix did not significantly improve the control of volunteers (Table 9), further reduce canola dockage (Table 12) or increase soybean yield (Table 15). In contrast, the best control of volunteer canola at Outlook was achieved by layering Viper ADV with a pre-seed herbicide tank mix. The check, sprayed pre-seed and in-crop with glyphosate alone, provided no control of canola, resulted in 44.8% dockage and produced a soybean yield of only 1524 kg/ha (Tables 9, 12 and 15). On average, a pre-seed tank mix without an in-crop application of Viper ADV provided 60% control of volunteers, reduced canola dockage down to 24.3% and increased yield to 2075 kg/ha. Layering Viper ADV with a pre-seed tank mix improved control of volunteers to 90%, further reduced dockage to 11.5% and maximized yield at 2570 kg/ha. Layering herbicide at Outlook increased soybean yield by 68%!

Figure 5. Main Effects of In-crop Herbicide on the Control of Volunteer Canola 56 days after Post-Emergent Herbicide Application

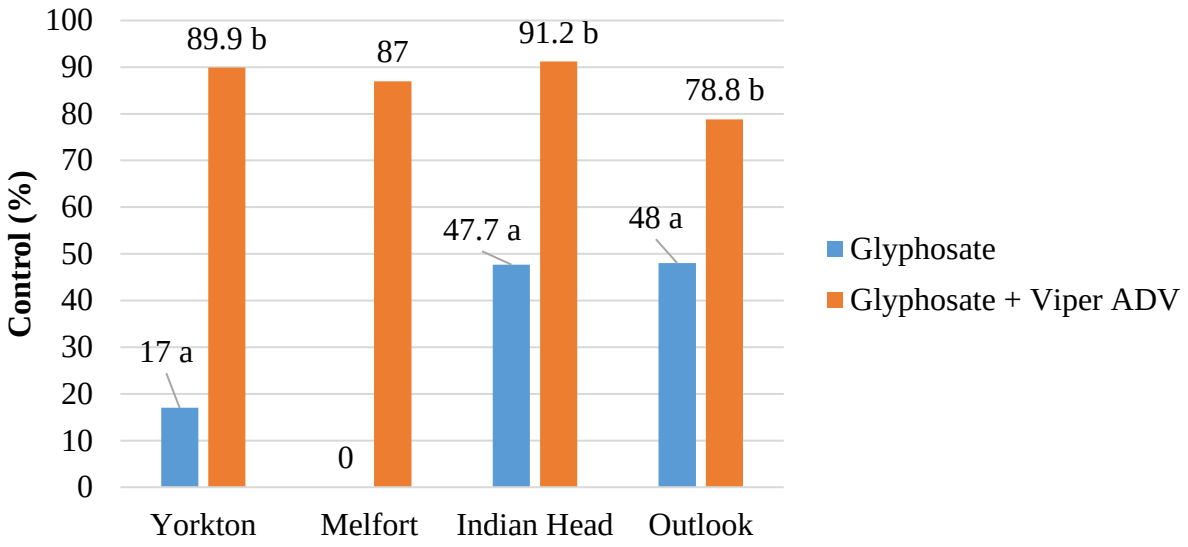


Figure 6. Soybean Dockage (%) for the Main Effects of In-crop Herbicide Control

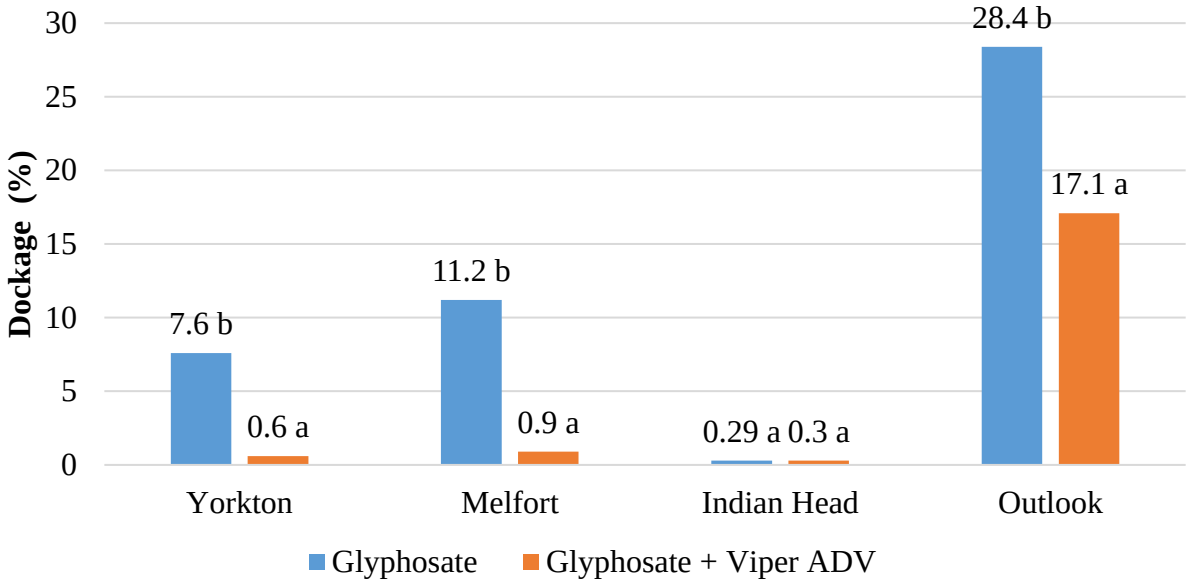
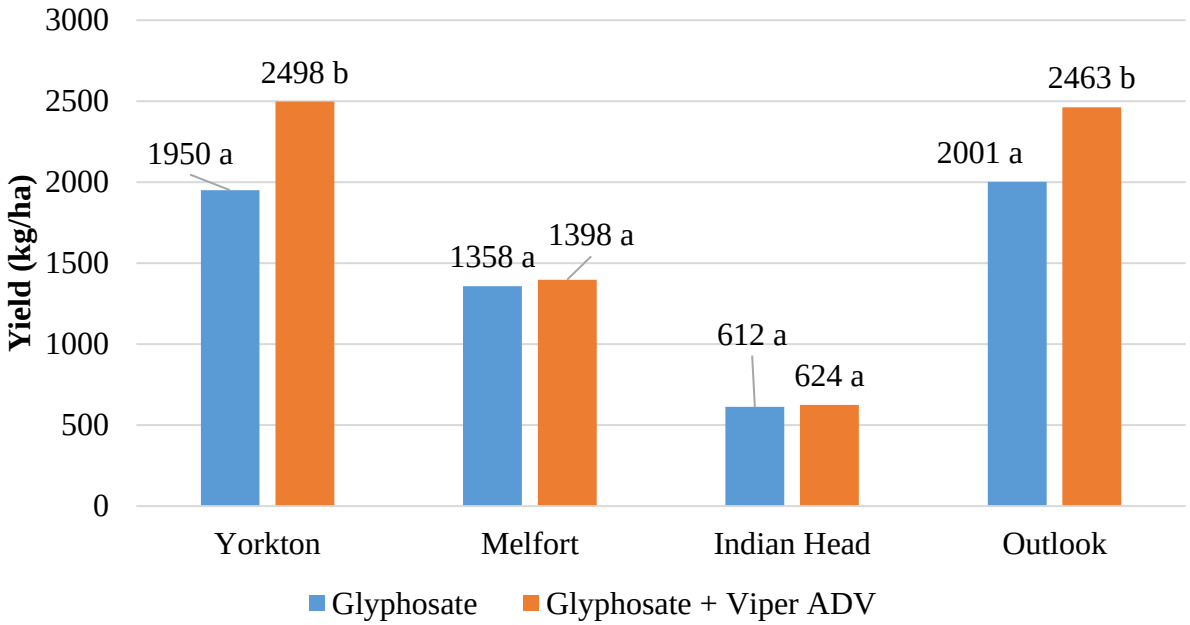


Figure 7. Soybean Yield for the Main Effects of In-crop Herbicide Control.



Conclusions and Recommendations

An in-crop application of Viper ADV without a pre-seed tank mix provided sufficient control of GR canola volunteers and maximized yield at Yorkton, Melfort and Indian Head because volunteers flushed late at Yorkton and Melfort and populations were low at Indian Head. In contrast, layering pre-seed herbicide tank mixes with an in-crop application of Viper ADV was extremely beneficial at Outlook under irrigation. At this location populations of canola volunteers were very heavy and there were multiple flushes. On average, pre-seed tank mixes alone provided 60% control of GR canola volunteers and increased soybean yield by 36%. However, layering pre-seed tank mixes with an in-crop application of Viper ADV further improved volunteer control to 90% and increased soybean yield by 68%. Layering of herbicides with different application timings and modes of action can increase control of canola volunteers and increase soybean yield. While differences between pre-seed tank mixes were significant at times, no consistent conclusion can be made regarding the relative efficacy of the products.

Supporting Information

10. Acknowledgements:

This project was funded through the Saskatchewan Pulse Growers and Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Adopt signs were posted during annual tours.

11. Appendices

Table 4. Significance of In-crop control (Viper ADV) and Pre-seed Tank Mixes on Control of Volunteer GR Canola 14 days after seeding (multiple locations 2018).

	Control 14 days after Seeding (%)			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
Effect	---------- p-values [z] ----------			
In-crop control Viper ADV (V)	0.0266	Ns	n/a	<0.0001
Pre-seed control (P)	0.0599	Ns	n/a	<0.0001
V x P	Ns	Ns	n/a	Ns

[z] p-values $\leq$ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 5. Main Effect Means for In-crop Control (Viper ADV) and Pre-seed control on Volunteer GR Canola 14 days after seeding (multiple locations 2018).

Main effect	**Control 14 days after Seeding**			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
In-crop control	---------- % ----------			
Glyphosate	26.0 b	13.8	n/a	69.8 a
Glyphosate + Viper ADV	8.8 a	10.0	n/a	74.0 b
LSD	15.0	Ns	n/a	2.0
Pre-seed control				
Glyphosate	0 a	0	n/a	0 a
Glyphosate + Blackhawk	8.8 ab	16.3	n/a	87.5 b
Glyphosate + Authority Charge	23.8 bc	13.8	n/a	91.3 c
Glyphosate + Express SG	20.6 abc	18.1	n/a	90.0 bc
Glyphosate + Heat LQ	33.8 bc	11.3	n/a	90.6 bc
LSD	23.8	Ns	n/a	3.1

Table 6. Means for the Interaction between In-crop control and Pre-seed control on Volunteer GR Canola 14 days after seeding (multiple locations 2018).				
Main effect	**Control 14 days after Seeding**			
	Yorkton	**Melfort**	**Indian Head**	**Outook**
V × P	---------- % ----------			
1.Glyphosate – Glyphosate	0.0	0.0	n/a	0.0
3.Glyphosate – Glyphosate + Blackhawk	12.5	10.0	n/a	85.0
4.Glyphosate – Glyphosate + Authority Charge	42.5	8.8	n/a	90.0
5.Glyphosate – Glyphosate + Express SG	27.5	30.0	n/a	86.3
6.Glyphosate – Glyphosate + Heat LQ	47.5	20.0	n/a	87.5
2.Glyphosate + Viper ADV– Glyphosate	0.0	0.0	n/a	0.0
7.Glyphosate + Viper ADV – Glyphosate + Blackhawk	5.0	22.5	n/a	90.0
8.Glyphosate + Viper ADV – Glyphosate + Authority Charge	5.0	18.8	n/a	92.5
9.Glyphosate + Viper ADV – Glyphosate + Express SG	13.8	6.3	n/a	93.8
10.Glyphosate + Viper ADV – Glyphosate + Heat LQ	20.0	2.5	n/a	93.8
L.S.D	33.7	Ns	n/a	4.4

Table 7. Significance of In-crop control (Viper ADV) and Pre-seed Tank Mixes on Control of Volunteer GR Canola 56 days after Post-emergent Herbicide Application (multiple locations in 2018).

Control 56 days after Post-emergent Herbicide Application (%)				
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
Effect	---------- p-values [z] ----------			
In-crop control Viper ADV (V)	<0.0001	<0.0001	<0.0001	<0.0001
Pre-seed control (P)	0.0711	Ns	0.0002	<0.0001
V x P	Ns	Ns	0.0146	Ns

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 8. Main Effect Means for In-crop Control (Viper ADV) and Pre-seed control on Volunteer GR Canola 56 days after Post-emergent Herbicide Application (multiple locations in 2018).

Main effect	**Control 56 days after Post-Emergent Herbicide Application**			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
In-crop control	---------- % ----------			
Glyphosate	17.0 a	0.0	47.7 a	48.0 a
Glyphosate + Viper ADV	89.9 b	87.0	91.2 b	78.8 b
LSD	7.1	3.5	11.1	7.0
Pre-seed control				
Glyphosate	44.8 a	42.5	75.4 bc	11.3 a
Glyphosate + Blackhawk	58.8 b	43.8	89.4 c	83.1 c
Glyphosate + Authority Charge	55.4 ab	43.8	70.5 b	81.9 bc
Glyphosate + Express SG	49.9 ab	43.8	69.4 b	69.4 b
Glyphosate + Heat LQ	58.5 b	43.8	42.5 a	71.3 b
LSD	11.2	NS	17.6	11.1

Table 9. Means for the Interaction between In-crop control and Pre-seed control on Volunteer GR Canola 56 days after Post-emergent Herbicide Application (multiple locations in 2018).				
Main effect	**Control 56 days after Post-Emergent Herbicide Application**			
	Yorkton	**Melfort**	**Indian Head**	**Outook**
V × P	---------- % ----------			
1.Glyphosate – Glyphosate	3.8	0.0	59.5	0.0
3.Glyphosate – Glyphosate + Blackhawk	28.8	0.0	83.8	70.0
4.Glyphosate – Glyphosate + Authority Charge	18.8	0.0	48.5	70.0
5.Glyphosate – Glyphosate + Express SG	12.5	0.0	40.0	50.0
6.Glyphosate – Glyphosate + Heat LQ	21.3	0.0	6.5	50.0
2.Glyphosate + Viper ADV– Glyphosate	85.8	85	91.3	22.5
7.Glyphosate + Viper ADV – Glyphosate + Blackhawk	88.8	87.5	95.0	96.3
8.Glyphosate + Viper ADV – Glyphosate + Authority Charge	92.0	87.5	92.5	93.8
9.Glyphosate + Viper ADV – Glyphosate + Express SG	87.3	87.5	98.8	88.8
10.Glyphosate + Viper ADV – Glyphosate + Heat LQ	95.8	87.5	78.5	92.5
L.S.D	15.8		24.9	15.7

Table 10. Significance of In-crop control (Viper ADV) and Pre-seed Tank Mixes on Canola Dockage (multiple locations in 2018).

	Dockage (%)			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
Effect	---------- p-values [z] ----------			
In-crop control Viper ADV (V)	<0.0001	<0.0001	Ns	0.0024
Pre-seed control (P)	Ns	Ns	Ns	<0.0001
V x P	Ns	Ns	Ns	Ns

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 11. Main Effect Means for In-crop Control (Viper ADV) and Pre-seed control on Canola Dockage (multiple locations in 2018).

Main effect	**Dockage**			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
In-crop control	---------- % ----------			
Glyphosate	7.6 b	11.2 b	0.29	28.4 b
Glyphosate + Viper ADV	0.6 a	0.9 a	0.30	17.1 a
LSD	1.0	2.2	Ns	6.9
Pre-seed control				
Glyphosate	5.0 a	5.9	0.26	42.1 b
Glyphosate + Blackhawk	4.6 a	6.0	0.28	20.6 a
Glyphosate + Authority Charge	3.7 a	6.1	0.30	13.6 a
Glyphosate + Express SG	4.3 a	6.1	0.32	18.7 a
Glyphosate + Heat LQ	3.1 a	6.2	0.31	18.7 a
LSD	NS	NS	NS	10.9

Table 12. Means for the Interaction between In-crop control and Pre-seed control on Canola Dockage (multiple locations in 2018).				
Main effect	**Dockage**			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
V × P	---------- % ----------			
1.Glyphosate – Glyphosate	8.8	11.2	0.24	44.8
3.Glyphosate – Glyphosate + Blackhawk	8.7	11.5	0.25	26.7
4.Glyphosate – Glyphosate + Authority Charge	7.1	11.9	0.30	15.0
5.Glyphosate – Glyphosate + Express SG	7.9	10.7	0.33	27.0
6.Glyphosate – Glyphosate + Heat LQ	5.8	10.9	0.31	28.5
2.Glyphosate + Viper ADV– Glyphosate	1.2	0.6	0.28	39.5
7.Glyphosate + Viper ADV – Glyphosate + Blackhawk	0.6	0.5	0.30	14.6
8.Glyphosate + Viper ADV – Glyphosate + Authority Charge	0.3	0.4	0.30	12.2
9.Glyphosate + Viper ADV – Glyphosate + Express SG	0.8	1.5	0.30	10.4
10.Glyphosate + Viper ADV – Glyphosate + Heat LQ	0.3	1.6	0.31	8.9
L.S.D	2.3	5.0	NS	15.4

Table 13. Significance of In-crop control (Viper ADV) and Pre-seed Tank on Soybean yield (multiple locations in 2018).

	Yield (kg/ha)			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
Effect	---------- p-values [z] ----------			
In-crop control Viper ADV (V)	<0.0001	Ns	Ns	<0.0001
Pre-seed Herbicide (P)	Ns	Ns	<0.0001	<0.0001
V x P	Ns	Ns	Ns	0.0014

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Table 14. Main Effect Means for In-crop Control (Viper ADV) and Pre-seed control on Soybean Yield (multiple locations 2018).

Main effect	**Yield**			
	Yorkton	**Melfort**	**Indian Head**	**Outlook**
In-crop control	---------- kg ha^{-2} ----------			
Glyphosate	1950 a	1358 a	612 a	2001 a
Glyphosate + Viper ADV	2498 b	1398 a	624 a	2463 b
LSD	200	NS	Ns	117
Pre-seed control				
Glyphosate	2154 a	1355 a	632 bc	1480 a
Glyphosate + Blackhawk	2348 a	1276 a	653 c	2558 c
Glyphosate + Authority Charge	2112 a	1448 a	599 b	2644 c
Glyphosate + Express SG	2183 a	1456 a	666 c	2294 b
Glyphosate + Heat LQ	2324 a	1356 a	539 a	2184 b
LSD	316	NS	45.7	184

Table 15. Means for the Interaction between In-crop control and Pre-seed control on Soybean Yield (multiple locations in 2018).

Main effect	**Yield**			
	Yorkton	**Melfort**	**Indian Head**	**Outook**
V × P	---------- Kg ha^{-2} ----------			
1.Glyphosate – Glyphosate	1855	1358	602	1524 a
3.Glyphosate – Glyphosate + Blackhawk	2051	1259	648	2231 c
4.Glyphosate – Glyphosate + Authority Charge	1913	1362	598	2388 cd
5.Glyphosate – Glyphosate + Express SG	1799	1481	688	1974 bc
6.Glyphosate – Glyphosate + Heat LQ	2133	1329	523	1890 b
2.Glyphosate + Viper ADV– Glyphosate	2453	1352	663	1436 a
7.Glyphosate + Viper ADV – Glyphosate + Blackhawk	2645	1293	658	2886 e
8.Glyphosate + Viper ADV – Glyphosate + Authority Charge	2311	1534	600	2901 e
9.Glyphosate + Viper ADV – Glyphosate + Express SG	2567	1431	645	2614 d
10.Glyphosate + Viper ADV – Glyphosate + Heat LQ	2516	1384	556	2479 cd
L.S.D	447	Ns	64.7	261

Abstract

12. Abstract/Summary:

Trials were established at Yorkton, Indian Head, Melfort and Outlook to demonstrate the benefit of layering herbicide for the control of glyphosate resistant (GR) canola volunteers in a glyphosate resistant soybean crop. The trials were established as a factorial design with 4 replicates. The first factor compared an in-crop application of glyphosate alone against glyphosate + Viper ADV. The second factor contrasted pre-seed applications of glyphosate alone and glyphosate tank mixed with either Blackhawk, Authority Charge, Express SG or Heat LQ. The benefit of layering herbicide could not be demonstrated at all locations. An in-crop application of Viper ADV alone was sufficient to maximize control of GR canola volunteers and maximize yield at Yorkton, Indian Head and Melfort. Layering with pre-seed tank mixes did little to improve control of volunteers or increase soybean yield as canola populations were low at Indian Head and the initial flush at Melfort and Yorkton emerged after the pre-seed herbicides had been applied. The situation was different at Outlook under irrigation, as a healthy population of volunteers was present when pre-seed herbicides were applied and canola continued to flush throughout the year. As a result, layering of herbicide was extremely beneficial at Outlook. On average, pre-seed tank mixes alone provided 60% control of GR canola volunteers and increased soybean yield by 36%. However, layering pre-seed tank mixes with an in-crop application of Viper ADV further improved volunteer control to 90% and increased soybean yield by 68%. While differences between pre-seed tank mixes were significant at times, no consistent conclusion can be made regarding the relative efficacy of the products.