wheatgrass herbicide screening report - “TOFU”

pilot study results • K8 • St Paul • 2022

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Objective

We wanted to spray wheatgrass with herbicides commonly used on the st paul campus. Some products we expected injury (acetochlor), other products we expected no injury (s-metolachlor) but wanted to do side by side comparisons with unsprayed wheatgrass plots to get some data.

Our hope was to find a corn/soy/small grain herbicide that could be used in wheatgrass without obvious injury and provide additional weed control options in unexpected research situations.

Wheatgrass weed control

As of 28Feb2023, 2,4-D is the only labelled herbicide in kernza and must be applied after tillering (4-8 inches tall) and before boot stage. This typically gives a 2 week window of 14May - 1June to control some broadleaf weeds in the spring.

Some herbicides labelled for “Grasses grown for seed” have been applied to kernza without obvious injury. Herbicides for perennial ryegrass, tall fescue, turf and other perennial grasses grown for seed are unlikely to cause injury. We tend to use products from the Winfield company; sometimes these generic products are not labelled for grasses grown for seed, but the original trade name product is labelled. For example, Dual Magnum herbicide is labelled for grasses grown for seed, but charger max herbicide is not labelled for grasses grown for seed even though both products contain the same active ingredient (s-metolachlor). This is true of Prowl as well.

What we already know

The 2017 herbicide screen at Estling Farms and Magnusson Farms found the following; full rate applications of Dual Boundary and Prowl resulted in slight delay of maturity for wheatgrass. Wolverine, Facet L and Axial XL had no effect on the crop.

Table 1: Herbicides labelled for grasses grown for seed production

Trade Names	Active Ingredients
Banvel	Dicamba
Bison	Bromoxynil Mcpa
Dimetric Liquid	Metribuzin
Dual	S-Metolachlor
Facet L	Quinclorac
Moxy	Bromoxynil
Prowl	Pendimethalin
Sharpen	Saflufenacil
Stingr	Clopyralid
Tacoma	Fenoxaprop
Zidua	Pyroxasulfone

Table 2: Herbicides used in this trial

Treatment Name	Active Ingredient
Acetochlor	Acetochlor
Boundary	S-Metolachlor Metribuzin
Dual	S-Metolachlor
Prowl	Pendimethalin
Axial Xl	Pinoxaden
Bison	Bromoxynil Mcpa
Dicamba	Dicamba
Facet L	Quinclorac
Wolverine	Bromoxynil Pyrasulfotole Fenoxaprop

The trial

Expected findings

We expected Dual, Prowl, Facet L, dicamba and Bison to show no injury when applied because they were labelled for grass grown for seed.

We also tested herbicides that we thought could cause injury.

Acetochlor is a PRE and POST product for corn. We thought acetochlor may cause injury because it is labelled for POST control of volunteer wheat.

Boundary is a PRE product for soybean. We thought Boundary would likely not cause damage because it is composed of two products that are seperately labelled for grasses grown for seed, s-metolachlor and metribuzin. It also showed no injury in 2017 trial.

Axial XL is a POST product for wheat and barley. We thought Axial XL may cause injury since it is labelled for POST control of grass weeds, however it showed no crop injury in 2017.

Wolverine is a POST product for wheat and barley. We thought Wolverine may cause injury since it is labelled for POST control of grasses like wild oat, but were told this product has been used without injury on wheatgrass for multiple years. No injury noted in 2017 trial.

We got busy with other experiments and the timing of our POST treatments was very late. Many of our POST labels recommend apply after tillering, which would be right at stem elongation (Zadocks 30). We were hoping to apply our POST treatments late as this would increase the liklihood of injury and more closely resemble a research scenario where a timing is late, but we wanted to apply around boot stage (Zadocks 40). These applications would still be on label, but more risky. However, we were so busy that we applied even later than we wanted too (such is research) and were already at seedhead emergence (Zadocks 52). At this point, we expected to observe wheatgrass injury even in the products labelled for grasses grown for seed. We expected to observe injury in all our POST treatments, especially in the group 4's (Bison, dicamba, Facet L)

Figure 1: PRE herbicides were applied on 19Apr2022. Plant tillering had occured in fall and these were given a Zadocks stage of 25. More tillering may have occured afterwards but it was not measured. Kernza is planted on 12" row spacing but there is a skip every 5th row, plots are centered on this skipped row.

Figure 2: POST herbicides were applied on 8Jun2022. The seedhead was about 25% emerged on most plants, Zadocks stage of 52

Method details

Wheatgrass was planted in 7Sep2021, sprayed about a month later with 2,4-D ester after a large flush of weeds (mostly lambsquarter and pigweed).

On 19Apr2022, PRE herbicides were applied and then wheatgrass injury was scored 30 days after application.

On 8Jun2022, POST herbicide treatments were applied and wheatgrass injury was scored again 7 days after application. Wheatgrass injury was scored on a scale of 0-10, where 10 was severe damage. Scoring was done blind by Jesse in spring, and by Jesse Cole and Lara in summer.

The weed abundance was also visually scored. The site for this trial was chosen because high weed pressure was expected, however there was very low weed pressure throughout the entire field during the study. The weed scores were meant to indicate relative differences in weeds among plots and if any sort of weed injury was visible. Due to low weed pressure, the weed-free plot treatment was not maintained and was managed identically to the weedy plots. There still were very few weeds (<1 plant per square meter). Due to the low weed pressure, the primary utility of the dataset is the wheatgrass injury data.

Herbicides were applied at maximum rates and the summer applications were about 1-2 weeks later than ideal and wheatgrass plants were already quite large and some seedheads were starting to emerge. The timing of the POST treatments were a worst case scenario and if no injury was observed in this study, it's very unlikely any injury will be observed.

In the following spring of 2023, there was a clear pattern of shattering in the field where some plots had many wheatgrass seedlings emerging and others had no wheatgrass seedlings. Shattering scores were recorded blind by Jesse to capture this unexpected pattern.

Limitations

This was a pilot study without sufficient replication to test interactions between PRE and POST treatments.

There is only 1 site-year of data, n=210.

Plot plan

10'

70'

	101	102	103	104	105	106	107
	acetochlor	acetochlor	acetochlor	acetochlor	acetochlor	acetochlor	acetochlor
	weed-free control	weedy control	dicamba	bison	wolverine	facet L	axial XL
	201	202	203	204	205	206	207
	prowl	prowl	prowl	prowl	prowl	prowl	prowl
	axial XL	weed-free control	wolverine	weedy control	facet L	bison	dicamba
	301	302	303	304	305	306	307
	dual	dual	dual	dual	dual	dual	dual
	wolverine	facet L	bison	weedy control	dicamba	weed-free control	axial XL
	401	402	403	404	405	406	407
	weedy control	weedy control	weedy control	weedy control	weedy control	weedy control	weedy control
	dicamba	weedy control	bison	facet L	axial XL	weed-free control	wolverine
	501	502	503	504	505	506	507
	boundary	boundary	boundary	boundary	boundary	boundary	boundary
	bison	axial XL	weedy control	dicamba	weed-free control	wolverine	facet L

6'

30'

PeWhe

W N S E

LegacyNet

PREs applied last week of April
POST applied first week of June
All applications at full labelled rates
weed-free treatments will be weeded by hand / hoe
visually score crop injury and weed injury and ground cover for wholeplot and subplot
possible: quantify dry biomass (crop and/or weed) % change from weedy+weed-free controls
possible: quantify yield change as % change from weedy+weed-free controls
possible: quantify % cover using canopeo
possible: fly drone over to detect changes in greenness + cool photo
only 1 rep, pilot study

Datasets

```
## Rows: 35
## Columns: 7
## $ experimental_unit <int> 101, 102, 103, 104, 105, 106, 107, 201, 202, 203, 20~
## $ PRE               <chr> "acetochlor", "acetochlor", "acetochlor", "acetochlo~
## $ POST              <chr> "weed-free control", "weedy control", "dicamba", "bi~
## $ date              <chr> "2022-05-19", "2022-05-19", "2022-05-19", "2022-05-1~
## $ weed_vis_score    <int> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0~
## $ iwg_injury        <int> 4, 4, 4, 4, 4, 4, 4, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0~
## $ person            <chr> "jesse", "jesse", "jesse", "jesse", "jesse", "jesse"~

## Rows: 105
## Columns: 7
## $ experimental_unit <int> 101, 102, 103, 104, 105, 106, 107, 201, 202, 203, 20~
## $ PRE               <chr> "acetochlor", "acetochlor", "acetochlor", "acetochlo~
## $ POST              <chr> "weed-free control", "weedy control", "dicamba", "bi~
## $ date              <chr> "2022-06-13", "2022-06-13", "2022-06-13", "2022-06-1~
## $ weed_vis_score    <int> 2, 1, 3, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0~
## $ iwg_injury        <int> 0, 0, 0, 3, 2, 7, 1, 1, 0, 1, 0, 0, 5, 3, 3, 2, 3, 0~
## $ person            <chr> "jesse", "jesse", "jesse", "jesse", "jesse", "jesse"~

## Rows: 35
## Columns: 5
## $ experimental_unit <int> 101, 102, 103, 104, 105, 106, 107, 201, 202, 203, 20~
## $ PRE               <chr> "acetochlor", "acetochlor", "acetochlor", "acetochlo~
## $ POST              <chr> "weed-free control", "weedy control", "dicamba", "bi~
## $ date              <chr> "2022-07-27", "2022-07-27", "2022-07-27", "2022-07-2~
## $ yield_kgha        <dbl> 680.8173, 672.7444, 497.8309, 600.0880, 853.0399, 57~

## Rows: 35
## Columns: 6
## $ experimental_unit  <int> 101, 102, 103, 104, 105, 106, 107, 201, 202, 203, 2~
## $ PRE                <chr> "acetochlor", "acetochlor", "acetochlor", "acetochl~
## $ POST               <chr> "weed-free control", "weedy control", "dicamba", "b~
## $ date               <chr> "2023-04-12", "2023-04-12", "2023-04-12", "2023-04-~
## $ shattering_vis     <int> 5, 7, 8, 6, 2, 5, 9, 6, 3, 5, 5, 0, 8, 9, 6, 4, 6, ~
## $ shattering_countm2 <dbl> 2348, 1761, 2348, 2935, 587, 587, 1761, 1174, 0, 58~
```

Spring data

Table 3: Wheatgrass injury scores collected by Jesse on 19May2022

PRE	injury	weed	n
boundary	0	0	7
dual	0	0	7
prowl	0	0	7
weedy control	0	0	7
acetochlor	4	0	7

Summer data

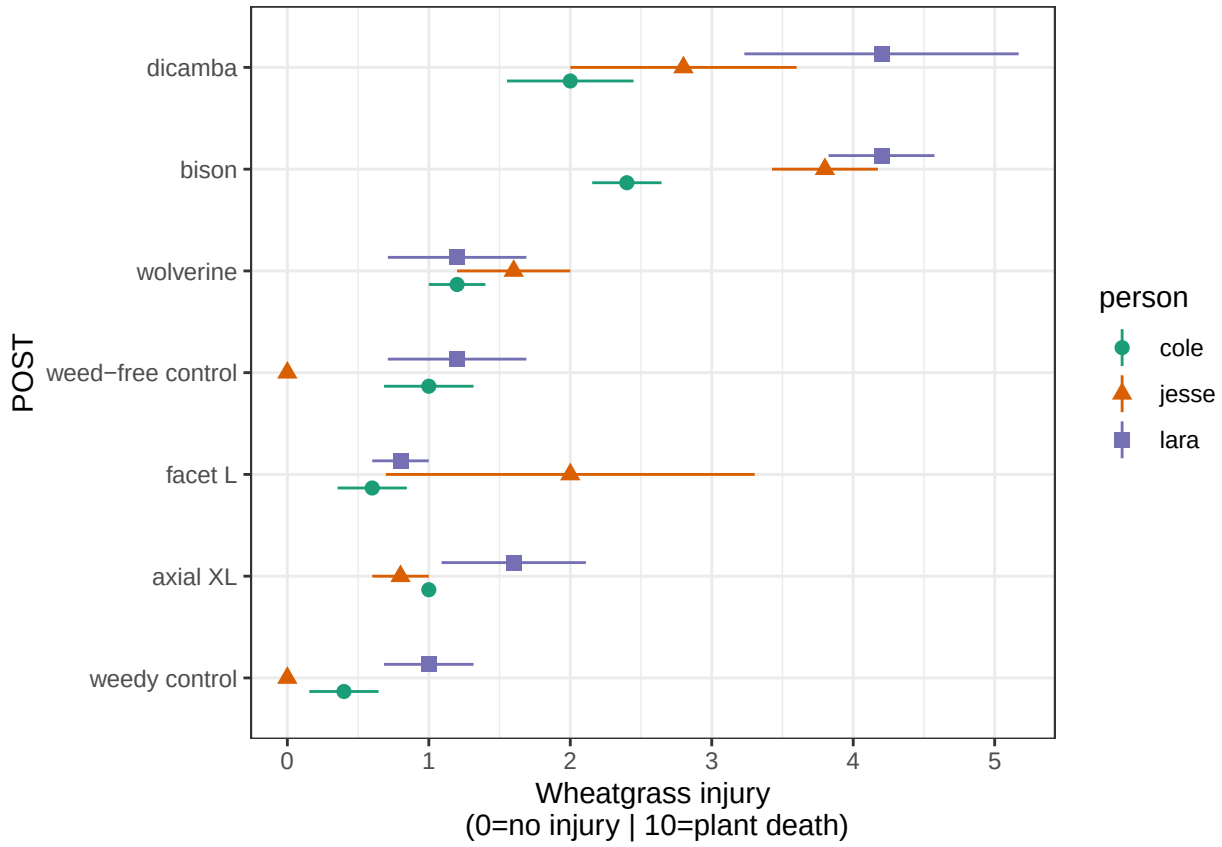

Figure 3: Wheatgrass injury scores after summer POST applications

Table 4: Wheatgrass injury scores collected by Jesse on 13Jun2022

POST	injury	weed	n
weedy control	0.5	0.6	15
weed-free control	0.7	1.0	15
axial XL	1.1	0.2	15
facet L	1.1	0.4	15
wolverine	1.3	0.2	15
dicamba	3.0	0.6	15
bison	3.5	0.6	15

Yield data

Table 5: ANOVA results for wheatgrass yields. An alpha level of 0.05 was used

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
PRE	4	288084.9	72021.23	3.072	0.035
POST	6	639240.4	106540.07	4.544	0.003
Residuals	24	562662.0	23444.25	NA	NA

Table 6: Wheatgrass yields did not differ among different PRE applications after adjusted for multiple comparisons

PRE	Yield (kg ha)	n
boundary	782 a	7
acetochlor	603 a	7
weedy control	595 a	7
dual	549 a	7
prowl	522 a	7

Table 7: Wheatgrass yields that share the same letter do not differ among POST applications

POST	Yield (kg ha)	n
wolverine	775 a	5
weedy control	704 a	5
facet L	680 ab	5
weed-free control	657 ab	5
axial XL	607 ab	5
bison	512 ab	5
dicamba	336 b	5

Shattering data

Table 8: ANOVA results for wheatgrass shattering visual scores. Count data was also collected and positively correlated with visual score data (r=.51), but I think visual score data was better at capturing shattering. An alpha level of 0.1 was used.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
PRE	4	29.829	7.457	1.976	0.130
POST	6	56.000	9.333	2.473	0.053
Residuals	24	90.571	3.774	NA	NA

Table 9: Wheatgrass shattering scores where 0 is no shattering and 10 is a lot of shattering. Data collected in April 2023.

PRE	shattering	SD	n
weedy control	8	2.3	7
boundary	7	1.1	7
dual	7	1.9	7
acetochlor	6	2.3	7
prowl	5	3.0	7

Table 10: Wheatgrass shattering scores where 0 is no shattering and 10 is a lot of shattering. Data collected in April 2023.

POST	shattering	n
axial XL	8 a	5
dicamba	8 a	5
weed-free control	7 ab	5
bison	7 ab	5
weedy control	7 ab	5
wolverine	6 ab	5
facet L	4 b	5

Figure 4: Plot 101, Visual score = 5, 24Apr2023

Figure 5: Plot 102, Visual score = 7, 24Apr2023

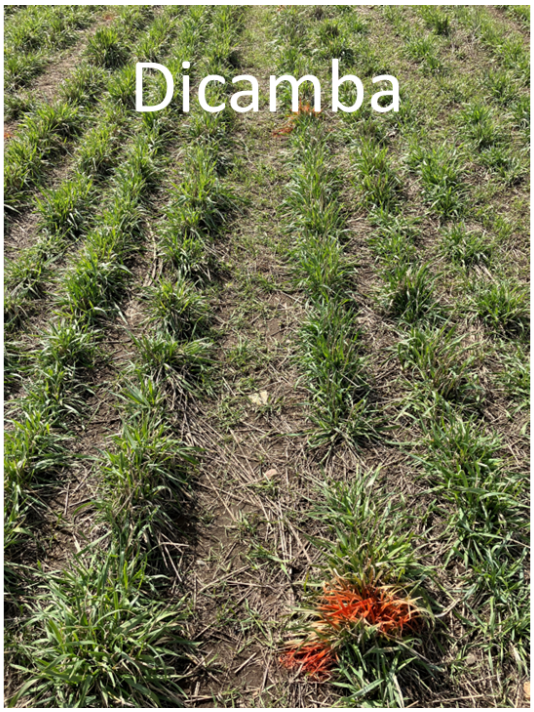

Figure 6: Plot 103, Visual score = 8, 24Apr2023

Figure 7: Plot 104, Visual score = 6, 24Apr2023

Figure 8: Plot 102, Visual score = 2, 24Apr2023

Figure 9: Plot 106, Visual score = 5, 24Apr2023

Figure 10: Plot 107, Visual score = 9, 24Apr2023

Findings

There are currently no labelled herbicides for grass control in wheatgrass. This trial supported previous findings from 2017 that Dual, Prowl and Boundary can be applied PRE to control grasses. Furthermore, Axial XL and Wolverine can be applied POST to control grasses even at a very late wheatgrass growth stage (Zadocks 52).

With the exception of acetochlor, the PRE herbicides did not cause any observable damage to the wheatgrass plant and yields did not differ from control. Months after application, wheatgrass plants that received an aceotochlor application were stunted. No delays in maturity were observed in the plots receiving high rates of Dual Boundary and Prowl.

All POST herbicides caused observable damage to the wheatgrass plant. Of these herbicides, Axial XL caused the least visible damage and yields did not differ between Axial XL and plots that received no herbicides. Plots receiving Bison and dicamba both had the greatest visual injury and the lowest yields.

Wheatgrass was resilient to maximum rates of unlabelled herbicides applied at times when the risk of crop injury was high. All plants produced grain and there were no obvious differences in grain yield in the field, though differences in grain yield were detected after threshing.

Shattering was lower where facet L was applied as a POST. This was an unexpected finding and may signal that facet L made the seeds infertile or that it provides residual control of wheatgrass seeds. Shattering also tended to be lower where Prowl was applied as a PRE, but this was not statistically significant.

Recommendations

Continuing to trial other herbicides labelled for grass seed production (Table 1) will provide valuable information.

The most injurious weeds to wheatgrass yield are likely winter annuals, which can be controlled with 2,4-D applied in the fall or early spring. The extent to which fall 2,4-D applications impact wheatgrass development is still unknown.

The primary reason to do further research into wheatgrass tolerance to grass herbicides is for the scenario we observed in the NALI experiment in 2022 where downy brome choked out the wheatgrass and alfalfa. In this scenario, we did not know there was a history of Downy Brome at this site. If we had a POST grass herbicide for Downy Brome that was safe on wheatgrass and alfalfa, it would've been able to save the study. Future research should look at other grass herbicides that could control downy brome and measure the effects of PRE and grass POST herbicides on establishing wheatgrass stands. Candidate herbicides would be Zidua, Verdict and dicamba.

Future projects

Fall applied 24D on establishing wheatgrass stands We apply different rates of 2,4-D at different timings starting about 21 days after planting. Measure tillering, plant height, maturity, biomass, yield.

Downy brome control in wheatgrass In Nali 1.0, if we abandon the site for 2.0. We apply Zidua, Verdict and dicamba at full rates. Measure weed injury, crop injury.

Wheatgrass plant back interval Apply 2,4-D to fields at full rates as a burndown, then plant kernza at different intervals after herbicide application (1 day, 10 day, 20 day). Measure plant counts, seedling vigor. Add in PRE treatments as well. If we find we can apply s-metolachlor pre-plant and still have wheatgrass emergence, this would give us another layer of protection, especially when planting a new field where we do not know the weed history like NALI.

TOFU follow-up Generate more data from POST treatments by using correct timing. Espeically interested in wheatgrass response to dicamba since dicamba may also have suppression on down brome.

Nrate X crop tolerance Weed control, especially in patchy or underfertilized wheatgrass stands can be helpful for ease of harvest, as large weeds can clog combine headers and add unwanted moisture to the grain tank.