Herbicide tolerance and weed control in lentil on sandy soils

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RESEARCH

Location
Alford, Yorke Peninsula
Soil Type
Red/grey alkaline sand with low organic carbon (0-10 cm) 0.94% and surface pH of 7.7 ($CaCl_2$)
Plot Size
The plots were 9.5 m x 1.5 m sown with knife points and press wheels on 250 mm spacing
Trial Design
Randomised complete block design consisting of 22 treatments x 3 replicates.

Key messages

- **Sandy soils can have narrow safety margins for commonly used broadleaved herbicides used in lentils. Herbicide damage from some group C and B herbicides reduced lentil growth and grain yield on a sandy soil at Alford on Yorke Peninsula.**
- **Herbicide efficacy on four weed species was variable between products. Herbicide combinations were required to provide high levels of control of all four weed species.**
- **Treatments that provided the highest levels of weed control also tended to have the largest negative effect on the crop.**
- **Optimising the herbicide strategy in lentils on sandy soils requires a balance between minimising crop effect and achieving acceptable weed control. This requires knowledge of the target weeds and their resistance status to determine which herbicides to use and in what combination. The benefit of high level weed control then needs to be weighed against the risk of herbicide damage to the crop.**

Why do the trial?

Herbicide damage in lentils can occur readily on sandy soils from both pre and post emergent applications. Low clay content, low organic carbon and low cation exchange capacity of sand hills predispose these areas to increased risk from herbicide damage. It is possible that even without visible plant injury symptoms there is an underlying level of herbicide damage restricting biomass production and yield of lentils on these soil types. Previous work conducted on a similar soil type in 2015 and 2017 showed that when more than one herbicide is applied the level of damage can be greater than the sum of the damage of the single herbicides on their own.

This trial aimed to test the safety level of several commonly used herbicide options and combinations on PBA Hurricane XT lentils.

How was it done?

The trial was sown with PBA Hurricane XT lentils on 21 May 2018 with 60 kg/ha MAP. The treatments included two rates of Group C herbicides Simazine900 (500 and 750 g/ha), Diuron900 (550 and 825 g/ha), Terbyne (500 and 750 g/ha) and Metribuzin (150 and 225 g/ha) applied 4 days pre-sowing (IBS), Group B herbicide chlorsulfuron (5 g/ha) applied IBS and Intervix (500 ml/ha) applied post emergent (9 July) and Group F herbicide diflufenican (150 ml) applied post emergent (14 June) and combinations of Simazine + Diuron and the Group B and F herbicides as per the treatment list (Table 1 and 2). Herbicide treatments were applied using a 2 m hand boom in 100 L water per ha.

Seven mm of rain fell between the IBS herbicide application and seeding. Plots were rolled prior to crop emergence.

Measurements throughout the season included visual herbicide damage scores, weed counts, GreenSeeker NDVI on 16 July, 4 August, 16 August and 5 September, pod drop prior to harvest, grain yield and general plant growth observations throughout the season.

Weed control of Wild turnip (*Brassica tournefortii*), Sow thistle (*Sonchus asper*), Medic (*Medicago spp.*) and Indian hedge mustard (*Sisymbrium orietale*) was assessed by plant counts when plots were hand weeded.

Results were analysed with the statistical package R.

What happened?

Herbicide damage

Significant levels of group C herbicide damage occurred at the site in 2018, even though all group C herbicides were applied IBS to improve crop safety (Table 1).

Herbicide damage scores show that there were significant differences between treatments at early growth stages with diuron being the safest of the group C herbicides evaluated in 2018.

The highest level of damage from any single group C herbicide occurred with Simazine900 at the high rate (750 g/ha) where there was a 23% reduction in NDVI compared with the untreated control on 16 July. This level of damage increased to 44% by early August and then remained at that level until the end of the season, where a 32% reduction in grain yield compared with the untreated control was observed (Table 1). High rates of metribuzin resulted in low levels of plant damage early, as measured by NDVI, but the plots recovered towards the end of the season. This was in contrast to the Terbyne treatment where damage started low but increased towards the end of the season. Diuron plots were not significantly affected at either rate, producing grain yields of 1.3 t/ha and similar to the untreated control. The crop safety of the simazine and diuron mixture (250/275 g/ha) was improved over the simazine applied as a standalone treatment.

The NDVI and grain yield data shows that Terbyne provided good levels of crop safety in 2018. However, observation of necrosis around the leaf margins in September suggests that had it been a wetter and longer growing season higher levels of plant damage may have occurred.

The group F herbicide treatment, diflufenican (Brodal) applied at 150 ml/ha early post emergent had a transient visual effect on the lentils in 2018. A reduction in NDVI of 9% on 4 August and 14% on 16 August compared with untreated control was observed, however no yield loss was observed. When diflufenican was applied in combination with group B or C herbicides, there was no increase in the level of damage to either of these herbicides when compared with their respective standalone treatments.

Of the group B herbicides, chlorsulfuron applied at 5 g/ha prior to sowing had higher levels of plant damage and yield loss than Intervix at 500 ml/ha, however, both resulted in significant reductions in NDVI, of 20% and 9% respectively by 4 August. The NDVI results on 5 September suggest that Intervix applied as a standalone treatment had recovered completely.

When the group B products were applied in combination with the group C mixture of simazine + diuron, the level of damage was cumulative. For example, the yield loss from simazine + diuron was 11% and the yield loss from Intervix was 8% and the yield loss of them combined was 19%. A similar result was observed with the chlorsulfuron and simazine+diuron combination. In contrast, when the group B herbicides Intervix and chlorsulfuron were applied in combination the effect was greater than the sum of each on their own, producing a 28% reduction in NDVI on 5 September and 55% reduction in grain yield.

Weed control

Turnip control ranged from 52% with the low rate of diuron to greater than 97% for Intervix or any combination with simazine + diuron mixtures (Table 2). There was no difference between any of the other group C products at either the high or low rate. Diflufenican also provided good control (97%).

Sow thistle control was poor with the use of chlorsulfuron alone with only 11% of weeds controlled. In comparison 88% control was achieved with Intervix. Of the group C herbicides metribuzin only controlled 35 and 69% of sow thistle weeds at 150 and 225 g/ha respectively, however higher levels of control were achieved with the other group C herbicides and diflufenican (83% control).

The sulphonyl urea (SU) product chlorsulfuron was the only individual treatment to provide high levels of medic control (98%), with Intervix next best at 74%. Most group C products struggled and provided suppression at best, but the combination of simazine + diuron followed by Intervix improved control to 94%.

The population of Indian hedge mustard (IHM) was sporadic across the trial site so there was poor statistical separation between treatments. However, chlorsulfuron alone and the low rate of metribuzin provided limited control.

What does this mean?

Herbicide damage from some Group C herbicide products caused significant biomass reductions and yield loss. The herbicide mixture of simazine + diuron at the lower rate provided a reasonable level of safety to the lentil crop and was still able to maintain good weed control for most species. Given the results recorded it may be possible to adjust the ratios of these two herbicides to reduce the amount of simazine to further improve crop safety and maintain weed control, however these results need to be considered with respect to the seasonal conditions too, where different rainfall patterns may produce a different result.

It was necessary to include some group B chemistry to get good control of the full spectrum of weeds, particularly medic, however it is important to note the impact this has on crop NDVI and the resulting grain yield. Intervix applied post emergent was the safest group B product in this trial.

Diflufenican in combination with the Group C mixture provided excellent control of the brassica weeds and had very good crop safety but provided poor control of medic.

The variation in efficacy between herbicide products and groups means it is important to know what weeds are present in the paddock and plan the herbicide strategy accordingly. Further to this, it is also important to know the herbicide resistance status of the target weeds. For example, Intervix has provided reasonable control of milk thistle and Indian hedge mustard at this site, however resistance to this herbicide is known to be increasing in these species and weed control failures will occur where this is the case unless alternative options can be used.

Figure 1 shows that for a given level of herbicide damage visible at flowering, as measured by a reduction in NDVI, there can be a variety of grain yield responses. The NDVI or biomass reduction from the combination of group B + C herbicides in 2018 had a much greater impact on grain yield compared to the same symptoms from the group C herbicides.

It is important to note that grain yields achieved were in the absence of weed competition, with plots hand weeded in mid-August, before the weeds imposed significant competition. The aim being to measure the effect of herbicide on crop performance, rather than the effect of weeds on crop yield. However, in a real paddock scenario where yields will reflect both crop effect from herbicide damage and remaining levels of weed competition, treatments that balance both crop damage and weed control are expected to perform better than the untreated control. The compromise between optimising weed control and minimising crop effect is highlighted in Figure 2, where group C herbicides that provided the best weed control also had the largest negative effect on crop yield. Weed competition in lentils can reduce yields close to zero where weeds are left uncontrolled and in high numbers. Previous research by the University of Adelaide at Minlaton, SA using triazine canola as a surrogate brassica weed showed that 10 canola plants per square metre reduced lentil yields by 15 to 26%.

Seasonal conditions have a large impact on weed emergence, herbicide efficacy and herbicide damage. Group C and B herbicides applied to sandy soils and incorporated by sowing (IBS) or post sowing and pre emergence (PSPE) are particularly sensitive to rainfall frequency and amounts. Therefore results should be interpreted with this in mind. Growing season rainfall was well below average, with the six week period post sowing being particularly dry. Results may differ in seasons with different seasonal conditions.

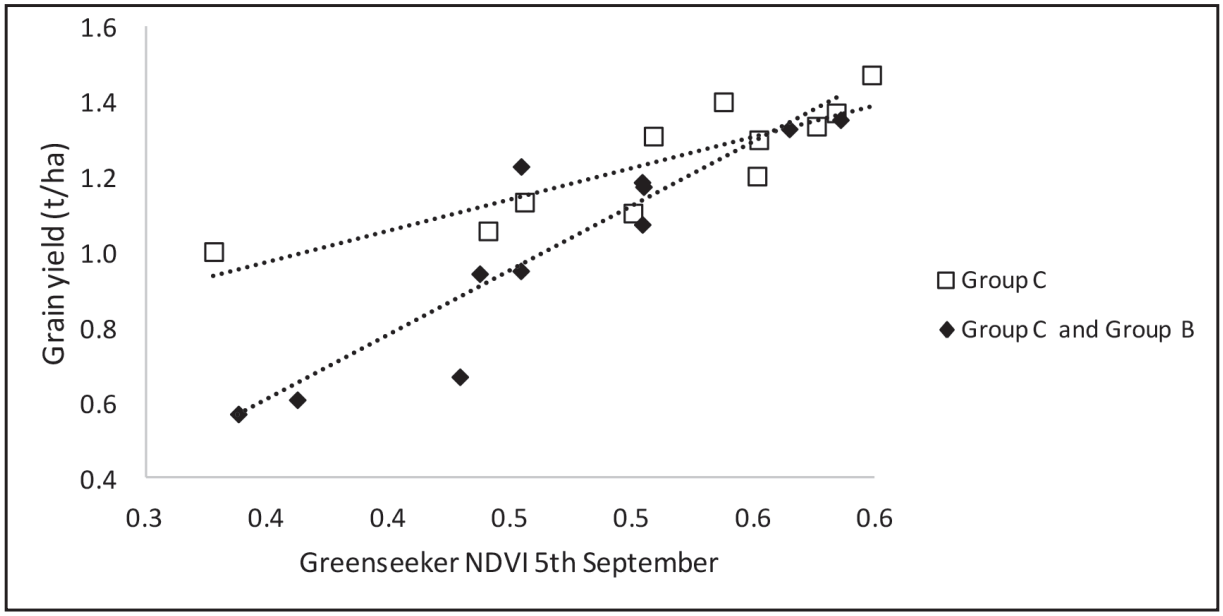

Figure 1 Lentil grain yield (t/ha) and Greenseeker NDVI 5 September (early flowering) for group C treatments only (y=1.668x + 0.3912 , R^2=0.7434) and Group B / Group C combinations (y=3.4308x – 0.5941, R^2=0.8418) at Alford in 2018

Table 1 Herbicide damage score (0=no symptoms, 6=plot death), Green seeker NDVI 16 July, 4 August and 5 September and grain yield (t/ha) for 2018 lentil herbicide tolerance trial at Alford, 2018

Treatment	Group C	Group C Rate (g/ha)	Diflufenican (ml/ha)	Chlorsulfuron (g/ha)	Intervix (ml/ha)	Damage score 14 June	Damage Score 2 July	NDVI 16 July	NDVI 4 Aug	NDVI 16 Aug	NDVI 5 Sept	Grain yield (t/ha)
1	Control					1.0	1.0	0.20	0.32	0.44	0.60	1.47
2	Simazine900	500				1.7	3.3	0.18	0.23	0.33	0.46	1.14
3	Simazine900	750				1.7	4.2	0.15	0.18	0.24	0.33	1.00
4	Diuron900	550				1.3	1.3	0.19	0.30	0.43	0.55	1.30
5	Diuron900	825				1.0	1.5	0.19	0.31	0.45	0.58	1.34
6	Terbyne	500				1.7	1.3	0.19	0.28	0.39	0.55	1.20
7	Terbyne	750				2.3	1.8	0.19	0.28	0.36	0.50	1.11
8	Metribuzin720	150				1.7	1.2	0.19	0.29	0.39	0.58	1.37
9	Metribuzin720	225				1.7	1.5	0.18	0.27	0.39	0.54	1.40
10	Sim/Diu	250/275				1.3	2.5	0.19	0.25	0.33	0.51	1.31
11	Sim/Diu	375/412.5				1.7	2.7	0.17	0.23	0.32	0.44	1.06
12				5		1.0	1.8	0.18	0.26	0.36	0.50	1.08
13					500	1.0	1.8	0.20	0.29	0.39	0.59	1.35
14	Sim/Diu	250/275		5		1.7	2.2	0.17	0.22	0.30	0.45	0.95
15	Sim/Diu	250/275			500	1.7	2.5	0.18	0.24	0.34	0.50	1.19
16				5	500	1.0	2.2	0.17	0.23	0.31	0.43	0.67
17	Sim/Diu	250/275		5	500	2.0	2.7	0.16	0.19	0.26	0.36	0.61
18			150			1.0	1.0	0.20	0.30	0.38	0.56	1.33
19	Sim/Diu	250/275	150			1.0	2.8	0.18	0.24	0.31	0.45	1.23
20	Sim/Diu	250/275	150	5		1.7	2.3	0.17	0.22	0.30	0.44	0.94
21	Sim/Diu	250/275	150		500	1.3	2.7	0.18	0.23	0.30	0.51	1.18
22	Sim/Diu	250/275	150	5	500	1.3	2.5	0.17	0.19	0.24	0.34	0.57
LSD (P=0.05)						*0.72*	*0.77*	*0.01*	*0.03*	*0.05*	*0.06*	*0.18*

Table 2 Weed control of Wild turnip (Brassica tournefortii), Sow thistle (Sonchus asper), Medic (Medicago spp.) and Indian hedge mustard (Sisymbrium orientale) presented as percent control, the same letters denote statistically similar results as analysed as log(weeds per plot +1) at the 5% level.

Treatment	Group C	Group C Rate (g/ha)	Diflufenican (ml/ha)	Chlorsulfuron (g/ha)	Intervix (ml/ha)	Wild turnip (% control)		Sow thistle (% control)		Medic (% control)		IHM (% control)	
1	Control					0.0	a	0.0	a	0.0	ab	0.0	a
2	Simazine900	500				76	bc	89	de	71	bcde	86	bc
3	Simazine900	750				79	bcd	99	gh	74	cde	99	c
4	Diuron900	550				52	ab	74	bc	26	abc	93	bc
5	Diuron900	825				72	bc	94	ef	54	abcde	97	bc
6	Terbyne	500				86	cd	84	cd	62	abcde	100	c
7	Terbyne	750				79	cd	96	fg	68	abcde	100	c
8	Metribuzin720	150				72	bc	35	a	23	a	29	ab
9	Metribuzin720	225				83	bc	69	b	45	abcd	82	bc
10	Sim/Diu	250/275				93	cd	90	de	59	cde	99	c
11	Sim/Diu	375/412.5				86	cd	93	ef	69	cde	91	bc
12				5		83	bcd	11	a	98	fgh	72	ab
13					500	97	cd	88	de	74	e	91	bc
14	Sim/Diu	250/275		5		97	cd	98	gh	98	fg	99	c
15	Sim/Diu	250/275			500	100	d	96	fg	94	f	97	bc
16				5	500	97	cd	96	fg	100	h	97	bc
17	Sim/Diu	250/275		5	500	100	d	100	h	100	h	97	bc
18			150			97	cd	83	bcd	34	abc	95	bc
19	Sim/Diu	250/275	150			100	d	100	h	74	de	100	c
20	Sim/Diu	250/275	150	5		100	d	99	gh	99	gh	100	c
21	Sim/Diu	250/275	150		500	100	d	100	h	96	fgh	100	c
22	Sim/Diu	250/275	150	5	500	100	d	100	h	100	h	100	c

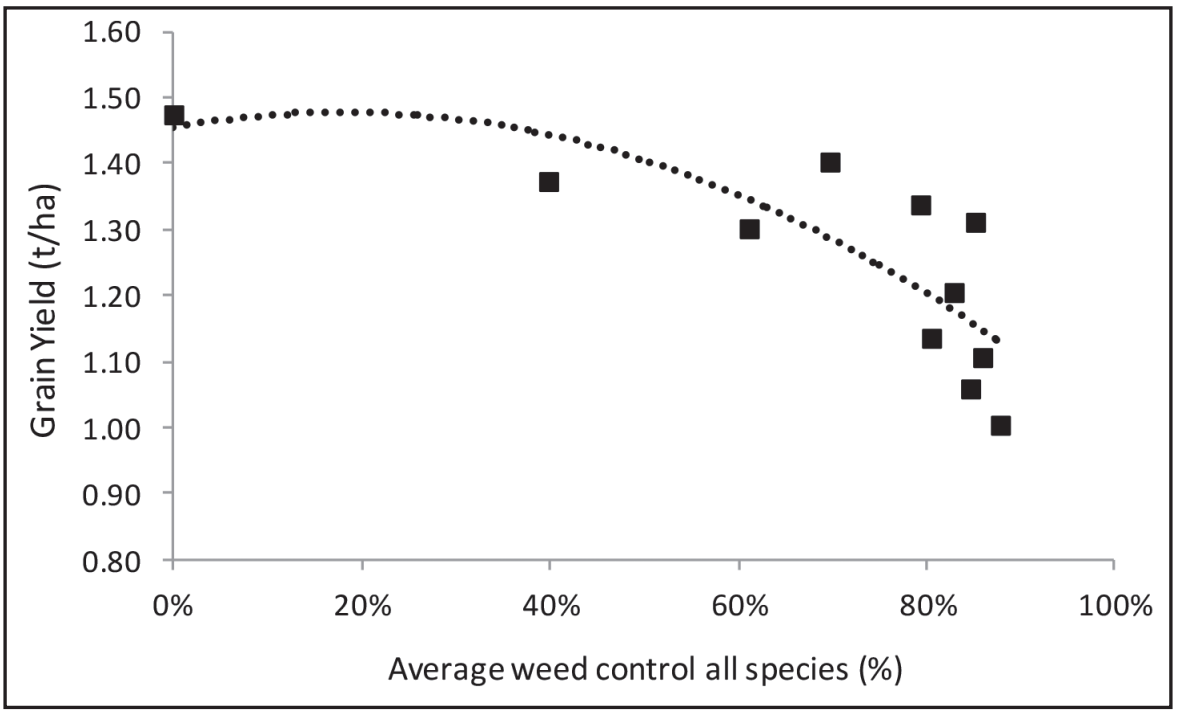

Figure 2 Effect of weed control of all species from Group C herbicides on grain yield (t/ha) of lentil at Alford, 2018. Y = -0.72x2 + 0.26x + 1.45, R2 = 0.60.

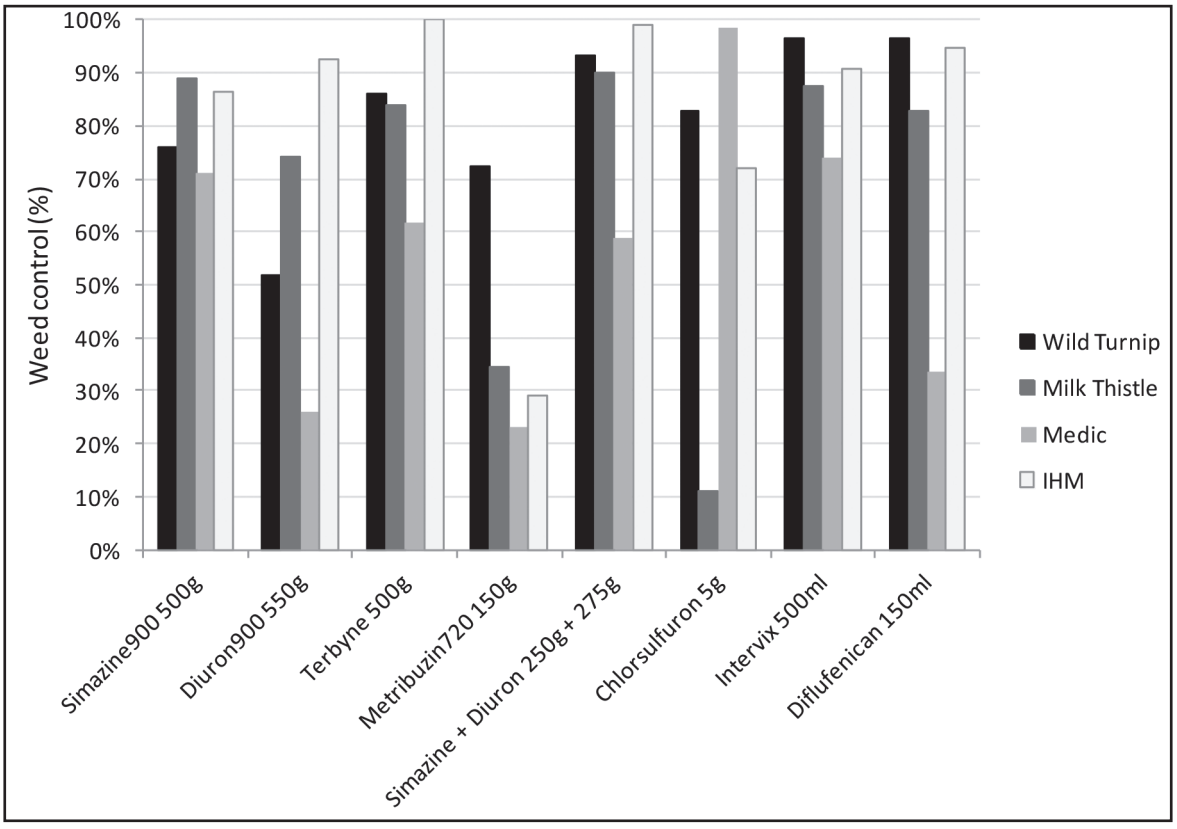

Figure 3 Weed control of four weed species with individual herbicides at Alford, 2018

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NOTE: Not all rates and herbicides used in this trial are registered for use in lentil and the results and findings reported in this article do not constitute a recommendation of their use by the authors.