

B9&10 Herbicide Tolerance, MRZ Hart and Pinery (Mid-North), South Australia

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Aim

To evaluate the field performance of the experimental herbicide tolerant faba bean line compared to the commercial variety Nura and the widely grown herbicide tolerant lentil variety, PBA Hurricane XT, to a range of simulated residual and in-crop applications of Group B herbicides.

Background

Following the success and rapid uptake of lentil varieties with the XT technology incorporating improved Group B herbicide tolerance, GRDC project DAS00131 has explored strategies to develop similar technologies in other pulse crops including faba beans. Currently there are no in-crop herbicide options for broad leaf weed control in faba beans and improved Group B herbicide tolerance similar to that developed in XT lentils would be of significant benefit to the industry. In 2011, DAS00131 discovered Group B herbicide tolerance in faba bean and this trait has now been widely incorporated into elite PBA breeding lines with the most advanced line, AF15369, progressed to the National Variety Trial (NVT) Program in 2016.

Treatments

Varieties: Faba beans varieties/lines- Nura (commercial variety used as a check), GpB-3, AF15369 (Adapted Herbicide Tolerance line); Lentil variety – PBA Hurricane XT (See also Table 1).
Plant density: 24 plants/m²
Sowing dates: Hart (Mid-North) – 16 May, Pinery (Mid-North) - 6 May,
Fungicides: 145 ml/ha Tebuconazole + 2.3 L/ha Chlorothalonil during the vegetative growth
2 L/ha Chlorothalonil + 500 ml/ha Carbendazim at pre flowering/canopy closure
Seed dressing: Nil
Row spacing: 22.5 cm
Plot size: 10 m x 1.75 m
Fertilizer: MAP + Zn (2%) @ 100 kg/ha at sowing
Soil type: Clay loam (Hart), Sandy Loam (Pinery)

Trial details

A range of Group B herbicides including; a) Sulfonylureas - four chemistries applied as simulated residuals, b) Imidazolinone - three chemistries at different rates applied post-emergent and c) Sulfonamide - one chemistry applied post-emergent on crops across the two sites (Table 2).

Measurements

Plant damage was assessed visually as symptomatic expression of chlorosis (%) at 2 weeks after treatment application (WAT) and at the commencement of flowering. This was measured on a 0 to 100 % scale (0 = no visible damage on plants and 100 % = complete plant mortality). A plant damage score of greater than 15% was considered agronomically unacceptable. Dry matter weight (t/ha) was measured by taking biomass cuts at the flowering stage and oven drying samples at 60°C for 48 hours. Grain yield was measured at physiological maturity.

Table 1: Crop varieties and characteristic used at Hart and Pinery (Mid-North), SA 2016.

Crop type	Variety	Comment	Tarlee	Hart
Faba bean	AF15369	Adapted HT line	√	√
	Imi-3	Parent HT line	√	
	Nura	Conventional variety	√	√
Lentil	PBA Hurricane XT	Adapted HT variety)	√	√

Table 2: Experimental Group B herbicides (simulated residuals and in-crop), application timings and rates in a faba bean and lentil herbicide tolerance trial at Hart and Pinery, SA, 2016.

Group B herbicides	Active chemical and application rate (gai/ha)	Application timing
	Nil	Nil
Sulfonylurea	SU-1 (R1)	Simulated residuals
	SU-2 (R1)	Simulated residuals
	SU-4 (R1)	Simulated residuals
	SU-3 (R1)	Simulated residuals
Imidazolinone	Imi-3 (R1)	Post emergent (4 to 5 Leaf)
	Imi-3 (R2)	Post emergent (4 to 5 Leaf)
	Imi-2 (R1)	Post emergent (4 to 5 Leaf)
	Imi-2 (R2)	Post emergent (4 to 5 Leaf)
	Imazethapyr (70)	Post emergent (4 to 5 Leaf)
	Imazethapyr (R2)	Post emergent (4 to 5 Leaf)
Sulfonamide	Tri-1	Post emergent (4 to 5 Leaf)

***** Note.** Some of the herbicide treatments in this research contain unregistered herbicides, application rates and timings and were undertaken for experimental purposes only. The results within this document do not constitute a recommendation for that particular use by the authors or authors' organisation and products not registered or permitted for use have been coded.

Results and discussion

- A combined analysis was conducted for similar crop varieties sown across the two sites. The GpB-3 line which was sown only at Pinery was analysed separately, data has not been included but inferences on its performance relative to the new experimental line AF15369 have been made in the discussion below.
- The herbicide tolerant lentil line, PBA Hurricane XT was used as a check to evaluate the tolerance level of the new faba bean lines. For purposes of logistics in managing the trial, the experimental layout was such that the lentil crop was laid at the back end of the two faba beans varieties/line and was not randomized at each site. During analysis, the trial was treated as two separate trials where the two crops were combined across the sites and analysed separately.
- A significant ($P < 0.001$) three way interaction, herbicide x variety x site was found for plant herbicide damage at commencement of flowering, when the highest symptomatic expression was observed. This indicated that the crop varieties differed in the level of plant damage from herbicide application but this was dependent on site factors such as inherent differences in soil type.
- AF15369 incurred no visual damage from all the herbicides evaluated when compared to the Nil treatment indicating a high level of tolerance across all sites.
- PBA Hurricane XT was sensitive only to the high post-emergent application rates of Imi-2 which caused significant chlorosis at Hart and Pinery (Table 3).
- In contrast, the commercial variety Nura showed varying and higher (>15 %) sensitivities to applications of most herbicides, with significant growth reductions and severe chlorosis observed when compared to its Nil treatment depending on site. Generally, Nura suffered more damage at Pinery compared with Hart and this may be related to differences in soil type.
- The sandy type soils found at Pinery site, are characteristically lower in organic matter, have less binding ability with herbicide thereby more likely to be available in the soil water increasing the risk to crop damage. On the other hand, heavier clay type soils such as at Hart site have more herbicide binding sites and generally result to less leaching and crop damage.
- Herbicides that showed lower levels of visual plant damage (<5 %) in Nura were SU-3 and the lower rates of Imazethapyr and Imi-3 (Table 3).
- AF15369 showed a similar level of response to herbicide treatments as its parent line, Imi-3 at Pinery (data not included), indicating that the herbicide tolerant trait had not been lost or reduced through introgression into adapted elite faba bean lines.
- Generally, grain yields of AF15369 (5.53, Hart and 5.61, Pinery t/ha) were higher than those of the Imi-3 line (4.6 t/ha) and Nura (4.2, Hart and 4.67 Pinery t/ha) in the absence of herbicide indicating improved agronomic traits in AF15369 line over the other two faba bean varieties/line.

- A significant three way interaction, herbicide x variety x site was similarly found for grain yield which indicated that the crop varieties differed in grain yield from herbicide application but this was also influenced by site factors.
- At Hart, grain yields of AF15369 were unaffected from the application of all sulfonylureas (applied as simulated residuals) and all imidazolinones (applied as post emergent) except for the high rate of sulfonamide product (applied as post emergence), which caused a significant reduction of 17 % (Table 4).
- At Pinery, grain yield of AF15369 was however reduced from the application of SU-1 (17%), SU-2 (16%) and high rate of Tri-1 (19%) indicating that the new adapted herbicide tolerant line has sensitivities to residuals depending on site/soil factors (Table 4).
- PBA Hurricane XT lentil showed no yield loss from the application of sulfonylureas, sulfonamide and all imidazolinones except for the high rates of Imi-2 (Table 5).
- When compared to the Nil treatment, Nura suffered significant grain yield loss ranging from 4 to 99 % at Hart and 13 to 97 % at Pinery indicating variability in sensitivities to chemistries in Group B herbicides.
- Application of simulated residual herbicides, SU-1, SU-2 and SU-3 led to significant grain yield loss greater than 50 % in Nura compared to the Nil treatment across the two sites. This highlights the huge impact residues have on susceptible crops such as Nura.
- The impact of residual herbicide SU-3 on the grain yield of Nura was dependent on site, where yields remained unaffected from its application at Hart, however a yield loss was incurred at Pinery when compared to the Nil treatment.
- Application of the low rate of Imi-3 as a post-emergence herbicide, had no effect on yields of Nura when compared to its Nil at both sites. Similarly, Imazethapyr applied post-emergence at low rate also had no effect on Nura at Pinery but not at Hart. All other herbicides (Imidazolinone and Sulfonamide) applied as post-emergence caused a significant yield loss in Nura when compared to its Nil treatment at the two sites.

Table 3: Effect of selected residual (simulated) and in-crop Group B herbicides on grain yield (t/ha) and plant damage (% chlorosis) of herbicide tolerant faba bean compared with commercial variety Nura and the Group B herbicide tolerant lentil PBA Hurricane XT at Hart SA, 2016.

		Chlorosis (%) at commencement of flowering					
		AF15369		Nura		PBA Hurricane XT	
Group B Herbicides	Experimental active & Application rate (gai/ha)	Hart	Pinery	Hart	Pinery	Hart	Pinery
	Nil	0	0	0	0	0	0
Sulfonylurea	SU-1 (R1)	0	0	37	40	0	8
	SU-2 (R1)	0	0	18	57	0	0
	SU-4 (R1)	0	0	27	53	0	3
	SU-3 (R1)	0	0	0	0	0	0
Imidazolinone	Imi-3 (R1)	0	0	0	0	0	0
	Imi-3 (R2)	0	0	33	70	7	3
	Imi-2 (R1)	0	0	40	67	0	3
	Imi-2 (R2)	0	0	77	87	57	30
	Imazethapyr (70)	0	0	2	7	0	3
	Imazethapyr (R2)	0	0	28	63	0	8
Sulfonamide	Tri-1 (R1)	0	0	15	30	0	2
LSD (P =0.05)		9.88				9	

Table 4: Grain yield of AF15369 and Nura following application of different Group B herbicide chemistries at Hart and Pinery SA, 2016.

		Square root				Raw Data			
		AF15369		Nura		AF15369		Nura	
Group B Herbicides	Experimental active & Application rate (gai/ha)	Hart	Pinery	Hart	Pinery	Hart	Pinery	Hart	Pinery
	Nil	2.35	2.37	2.16	2.05	5.53	5.61	4.67	4.22
Sulfonylurea	SU-1 (R1)	2.23	2.15	0.92	1.16	4.99	4.61	0.84	1.34
	SU-2 (R1)	2.24	2.17	1.41	1.23	5.02	4.71	1.99	1.51
	SU-4 (R1)	2.24	2.29	0.56	0.63	5.01	5.23	0.32	0.40
	SU-3 (R1)	2.29	2.31	2.02	1.75	5.25	5.32	4.09	3.07
Imidazolinone	Imi-3 (R1)	2.29	2.26	2.11	1.91	5.23	5.11	4.44	3.63
	Imi-3 (R2)	2.30	2.34	1.83	1.51	5.27	5.47	3.34	2.27
	Imi-2 (R1)	2.40	2.29	1.38	1.19	5.76	5.23	1.90	1.41
	Imi-2 (R2)	2.29	2.39	0.20	0.36	5.22	5.69	0.04	0.13
	Imazethapyr (70)	2.35	2.43	1.91	1.90	5.54	5.89	3.65	3.61
	Imazethapyr (R2)	2.32	2.32	1.55	1.59	5.40	5.38	2.39	2.54
Sulfonamide	Tri-1 (R1)	2.13	2.13	1.79	1.59	4.55	4.53	3.19	2.54
LSD (P =0.05)		0.168							

Table 5: Grain yield of PBA Hurricane XT averaged across two sites, Hart and Pinery SA, 2016.

Group B Herbicides	Experimental active & Application rate (gai/ha)	PBA Hurricane XT
	Nil	3.3
Sulfonylurea	SU-1 (R1)	3.1
	SU-2 (R1)	3.3
	SU-4 (R1)	3.4
	SU-3 (R1)	3.4
Imidazolinone	Imi-3 (R1)	3.3
	Imi-3 (R2)	3.2
	Imi-2 (R1)	3.5
	Imi-2 (R2)	2.8
	Imazethapyr (70)	3.4
	Imazethapyr (R2)	3.6
Sulfonamide	Tri-1 (R1)	3.4
LSD (P =0.05)		0.19

Conclusions

- The three crops that were tested, faba bean varieties, Nura and AF15369 and lentil variety, PBA Hurricane XT differed in the level of plant damage and grain yield from application of a range of Group B herbicides applied as simulated residual or in-crop applications. This indicated that a large genetic variation exist between the varieties tested.
- The interaction between soil type and Group B herbicide chemistry was significant as it influenced herbicide activity and its ability to cause crop damage and grain yield loss in faba bean varieties/lines. More crop damage and yield loss was observed at Pinery where the soils are sandy and low in organic matter, have less binding ability and a higher risk of leaching. In comparison, less crop damage was observed at Hart which may be explained by the characteristically heavy clay type soils with more herbicide binding sites with less risk to leaching.
- AF15369 had improved level of tolerance demonstrated by the lack of damage from application of Sulfonylureas and imidazolinone chemistries, (at Hart only) compared to Nura which had variable and significant amounts of herbicide damage across the two sites.
- AF15369 suffered a significant reduction in grain yield from the application of sulfonylureas chemistries, SU-1 (17 %) and SU-2 (16 %) at Pinery but not at Hart indicating that there are sensitivities in residual Group B herbicides in the new adapted herbicide tolerance line depending on soil type. Sound agronomic principles of adherence to plant back periods and adapting a whole farming system approach while planning crop rotations will be required in managing the new line together with other sensitive pulse crops/varieties.
- AF15369 and Nura showed genetic similarities in the level of improved tolerance to the application of simulated residues of SU-2, and post emergence application of Imi-3 (R1) and this was consistent across the two sites.
- Grain yield of Nura was not affected by post emergence application of Spinnaker at the low rate, at Pinery but not at Hart where grain yields were reduced by 11%. This indicates that even with registered Group B herbicides such as Spinnaker, the interaction between soil type and herbicide activity was important and therefore broadleaf weed control in pulse crops will require a judicious approach with sound agronomic principles.
- The sulfonamide product, which is associated with a narrow weed control spectrum, reduced the yields of AF15369 faba bean line (17 % at Hart and 19 % at Pinery) but there was no yield reduction in PBA Hurricane XT lentil.
- Genetic similarities were observed between AF15369 and the XT lentil which showed similar and high level of in-crop tolerance to all Imidazolinone chemistries tested, except Imi-2 applied at high rates, which caused significant plant damage and grain yield reductions in PBA Hurricane XT lentil but not in AF15369.

- These results in combination with similar findings from trials elsewhere in SA and Victoria indicate that the herbicide tolerant trait in faba beans is likely to contribute to improved weed control in Australian farming systems.
- The increase in grain yield of AF15369 by 15 % at Hart and 24 % at Pinery over Nura, in the absence of any herbicide application suggests that this herbicide tolerant line has superior agronomic traits with good adaptation and yield potential for southern Australian faba bean growing environments. This was also supported by similar findings in over 20 NVT trials across this region in 2016.
- The improved tolerance in new adapted faba bean line to imidazolinone could allow alternative in-crop weed control options to be developed for faba beans. The tolerance to residual activity to Sulfonylureas, is also likely to reduce the residue implications from using this chemistry in the cereal phases of rotations, albeit soil type considerations are required, further enhancing the weed control options across the whole farming system.
- Further evaluation of the field tolerance of AF15369 against commercial faba bean varieties as well as other XT lentil lines, will continue over the coming seasons to characterize tolerance levels to a range of Group B chemistries across variable seasons and soil types. Given the rapid uptake of the XT lentil technology, and the lack of current in-crop broadleaf weed control options in faba beans it is likely that this technology will be rapidly up taken in faba bean. However further research and investment is required to obtain the necessary regulatory approvals to accompany this technology in this crop.
- **Importantly, existing product labels, plant-back periods and directions for use must still be adhered to. Although current and previous results indicate that XT lentil varieties show improved tolerance to residual and in-crop Group B chemistries compared to conventional varieties, it is worth noting that yield loss still incurred in some situations such as application of high rates of Imi-2 (R2) as observed in this trial. This indicates a low safety margin to this chemistry and potentially others in this herbicide group. As such further research is required to identify if sufficient crop safety exists in XT lentils to seek changes to label recommendations for other Group B herbicides.**