Imidazolinone-tolerant lentils– Wagga Wagga 2014

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Key findings

- Yield of PBA Ace$^{\Phi}$ and PBA Jumbo2$^{\Phi}$ (the only two imidazilinone or IMI-sensitive varieties evaluated) was reduced by 70%–80% from applying imazethapyr.
- PBA Hurricane XT$^{\Phi}$ and PBA Herald XT$^{\Phi}$ are the only current commercial IMI-tolerant varieties. PBA Hurricane XT$^{\Phi}$ is better adapted, producing more dry matter and grain yield than PBA Herald XT$^{\Phi}$ in southern NSW.
- CIPAL1422 is a promising advanced Coordinated Improvement Program for Australian Lentils (CIPAL) breeding line with high grain yield. It is very IMI-tolerant, and tall and bulky with late maturity.
- Advanced breeding lines are equal to, or better than, PBA Ace$^{\Phi}$ and PBA Jumbo2$^{\Phi}$ in southern NSW. They bring additional features such as herbicide tolerance, extra bulk and height, and a wider range of maturity.
- IMI herbicide tolerance will expand weed-control options in lentil, which is a poorly competitive crop with a limited number of registered herbicides.
- These new varieties, coupled with new technologies, demonstrate considerable potential for expanding lentils across the better class of acidic, red-brown soils of southern NSW.

Introduction

This experiment evaluated the two new imidazolinone (IMI) herbicide-tolerant lentil varieties PBA Herald XT and PBA Hurricane XT alongside other commercial varieties and breeding lines for adaptation and production in southern NSW.

Both varieties have the potential to widen weed control options due to their tolerance to the Group B herbicides imazethapyr (e.g. Spinnaker® and Belta®) and flumetsulam (e.g. Broadstrike®). They are also less sensitive to the carryover residues of some sulfonylurea (e.g. Glean® and Logran®) and imidazolinone (e.g. Raptor®) herbicides applied in previous years.

Site details

Site	Paddock 20A, Wagga Wagga Agricultural Institute
Sowing date	8 May 2014
Soil type	Red-brown earth, pH_{Ca} 5.2 (0–10 cm) (Table 1). The site was limed in 2010
Design	Randomised complete block design with herbicide as the main blocks and varieties as the sub-plots; three replications
Paddock history	Sown to pasture in autumn 2013 but poor establishment led to chemical fallowing of the paddock in the spring. Therefore, stubble was absent for the 2014 season
Fertiliser	80 kg/ha SuPerfect® grain legume fertiliser (NPKS 0:13.8:0:6.1) placed 2 cm below the seed at sowing
Plant population	Target 120 plants/m^2
Sowing	Direct-drilled using a six-row cone seeder with 300 mm row spacing, press wheels and GPS auto-steer
Inoculation	Group F peat inoculant was mixed directly into an on-board 200 L water tank then pumped into each sowing furrow through micro-tubes

Weed management	Commercial weed management practices used to maintain weed-free conditions throughout the trial, eliminating weed competition and weed seed set. Fallow weed control: 2 L/ha glyphosate (450 g/L) and 1 L/ha 2,4-D LV ester (680 g/L) Incorporated by sowing: 2 L/ha glyphosate (450 g/L), 2 L/ha Stomp® (440 g/L pendimethalin), 2 L/ha Avadex® (400 g/L tri-allate) and 1 kg/ha Terbyne® (750 g/kg terbuthylazine) Post emergent: 330 mL/ha Select® (240 g/L clethodim), 100 mL/ha Verdict® (520 g/L haloxyfop) and 500 mL/100 L Uptake® spraying oil
Insect management	Targeting *Helicoverpa* sp.: 400 mL/ha Fastac® Duo (100 g/L alpha-cypermethrin) – 20 September and 24 October

Treatments

Varieties (54)	4 varieties:	PBA Ace$^{\Phi}$ PBA Jumbo2$^{\Phi}$ PBA Herald XT$^{\Phi}$ PBA Hurricane XT$^{\Phi}$
	3 CIPAL lines:	CIPAL1421 CIPAL1422 CIPAL1423
	47 PBA breeding lines	
Herbicides (2)	'Plus' and 'Minus' Belta® 700 WG (700 g/kg imazethapyr) applied at 400 g/ha on 22 June when seedlings were 3–5 cm high (**NB**: this is four times the highest recommended rate)	

Soil

Pulse growth and rhizobia survival can be affected when soil pH falls below five. This can lead to problems on the acidic, red-brown soils that dominate the cropping zones of southern NSW. Growers need to consider this and routinely monitor soil acidity to maintain a base pH of approximately five by strategically incorporating lime. The 2014 Wagga Wagga site was limed in 2010 and its top soil (0–10 cm) pH_{Ca} is now 5.2. Soil nitrogen levels were low and phosphorus levels medium (Table 1).

Table 1. Site soil chemical characteristics for 0–10 cm and 10–20 cm depth at Wagga Wagga, 2014.

Characteristic	Depth	
	0–10 cm	10–20 cm
pH_{Ca}	5.2	5.0
Aluminium Sat (%)	1.7	2.5
Nitrate nitrogen (mg/kg)	8.5	15
Ammonium N (mg/kg)	0.8	1.1
Phosphorus (Colwell) (mg/kg)	34	13
Cation exchange capacity (CEC) (cmol(+)kg)	7.0	6.5

Season

The 2014 season at Wagga Wagga was warmer, drier and shorter than normal (Figure 1, *Faba bean time of sowing Wagga Wagga 2015*). Early season rainfall (March–June) was 40% above the long-term average and, in combination with the mild temperatures during this period, conditions were ideal for plant establishment and early growth. This rain also replenished sub-soil moisture, benefiting grain fill at the end of the season when July to October rainfall was only half (93 mm) the long-term average. Crops finished 2–3 weeks earlier under these low rainfall and warm temperatures (1–2 °C above average).

There were 43 frost events in 2014 when temperatures fell below 2 °C. More severe frost occurred in July and August (18 events when temperatures dropped below 0 °C) causing isolated stem-splitting and some flower and pod loss. A further three significant frosts occurred in September (temperatures fell below –1 °C on 4, 19 and 20 September). Further flower and pod loss occurred as a result of these events; however, moisture and high temperature stresses ultimately became the overriding limitations to grain fill and yield.

These conditions were not conducive to disease and incidence was low.

Results

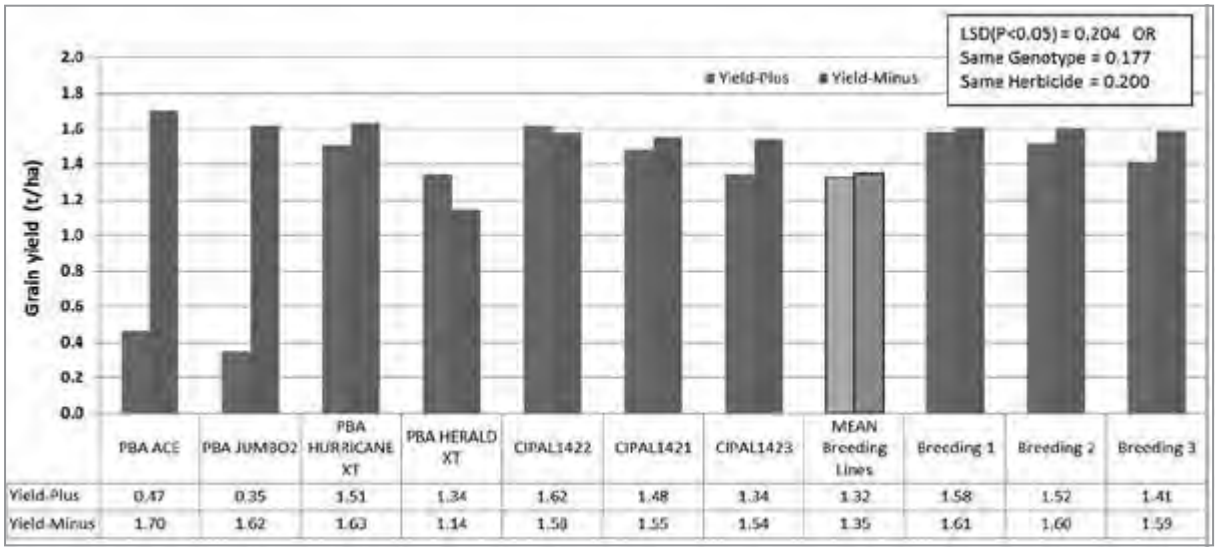
A total of 54 lentil varieties and breeding lines were evaluated for adaptation to southern NSW and tolerance to the IMI type herbicides. The trial was sown on 8 May and sprayed with 400 g/ha Belta® 700 WG (700 g/kg imazethapyr) on 22 June when seedlings were 3–5 cm with 3–4 true leaves. This is four times the highest recommended rate for this herbicide, considered sufficient to experimentally expose sensitivities in the 54 entries. Only the two controls PBA Ace and PBA Jumbo2 incurred significant damage: grain yield reduced by 70–80% (figures 1 and 2); green foliage cover normalised difference vegetation index (NDVI) reduced by 35–40%

(Figure 3); height scores almost halved (Table 2) and maturity significantly delayed (field observations). In comparison, PBA Herald XT and PBA Hurricane XT, along with all breeding lines, displayed a high level of tolerance to this same high rate of imazethapyr.

Breeding this new generation of lentil varieties has incorporated tolerance to Group B herbicides such as imazethapyr (e.g. Spinnaker® and Belta®) and flumetsulam (e.g. Broadstrike®), providing increased weed control options. This is particularly important in a poorly competitive crop with a limited number of registered herbicides. These breeding lines also have reduced sensitivity to some sulfonylurea herbicides (e.g. Glean®and Logran®) and imidazolinone herbicides (e.g. Raptor®). This has particular relevance in reducing the likely risk of lentil crop damage and yield loss from residues from these herbicides.

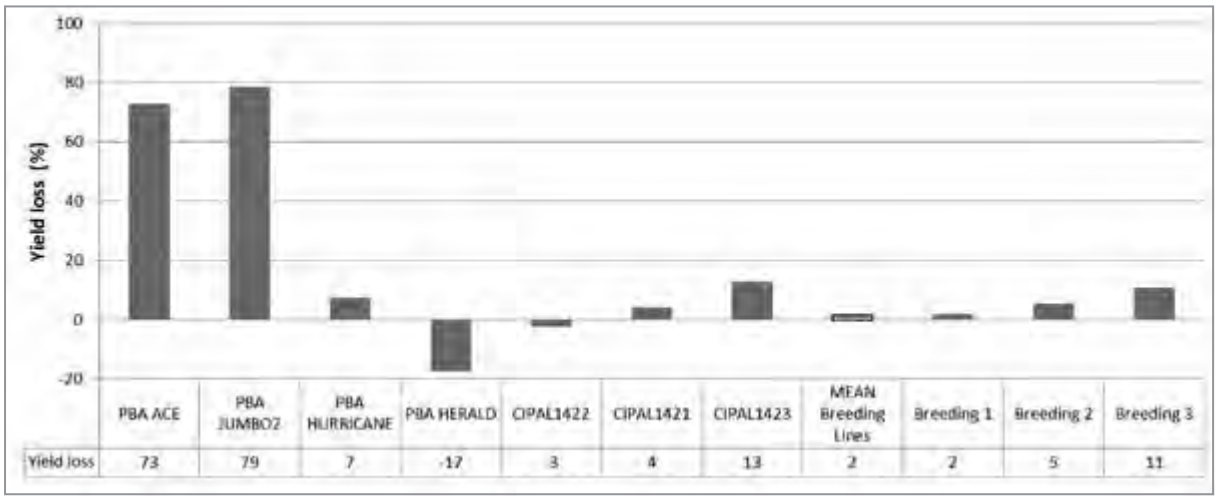
PBA Hurricane XT and PBA Herald XT are currently the only commercial IMI-tolerant varieties available in Australia. PBA Hurricane XT is the more recently released of the two and these results confirm it is better adapted, produces greater green foliage groundcover (NDVI) and yields more grain in southern NSW (figures 1, 2 and 3).

CIPAL1422 is a promising advanced-breeding line with a high grain yield. It has IMI-tolerance, and is tall and bulky with a very high NDVI reading. It is also a late maturing variety, and one of the highest yielding lines in the Plus and Minus treatments (figures 2 and 3).



	PBA ACE	PBA JUMBO2	PBA HURRICANE XT	PBA HERALD XT	CIPAL1422	CIPAL1421	CIPAL1423	MEAN Breeding Lines	Breeding 1	Breeding 2	Breeding 3
Yield-Plus	0.47	0.35	1.51	1.34	1.62	1.48	1.34	1.32	1.58	1.52	1.41
Yield-Minus	1.70	1.62	1.63	1.14	1.58	1.55	1.54	1.35	1.61	1.60	1.59

Figure 1. Grain yield of lentils (four commercial varieties, three CIPAL and three breeding lines) treated with 400 g/ha Belta® 700 WG (Plus) or untreated (Minus), Wagga Wagga, 2014.



	PBA ACE	PBA JUMBO2	PBA HURRICANE	PBA HERALD	CIPAL1422	CIPAL1421	CIPAL1423	MEAN Breeding Lines	Breeding 1	Breeding 2	Breeding 3
Yield loss	73	79	7	-17	3	4	13	2	2	5	11

Figure 2. Lentil yield losses (four commercial varieties, three CIPAL and three breeding lines) from a post-emergent treatment with 400 g/ha Belta® 700 WG (700 g/kg Imazethapyr) on 22 June, Wagga Wagga 2014.

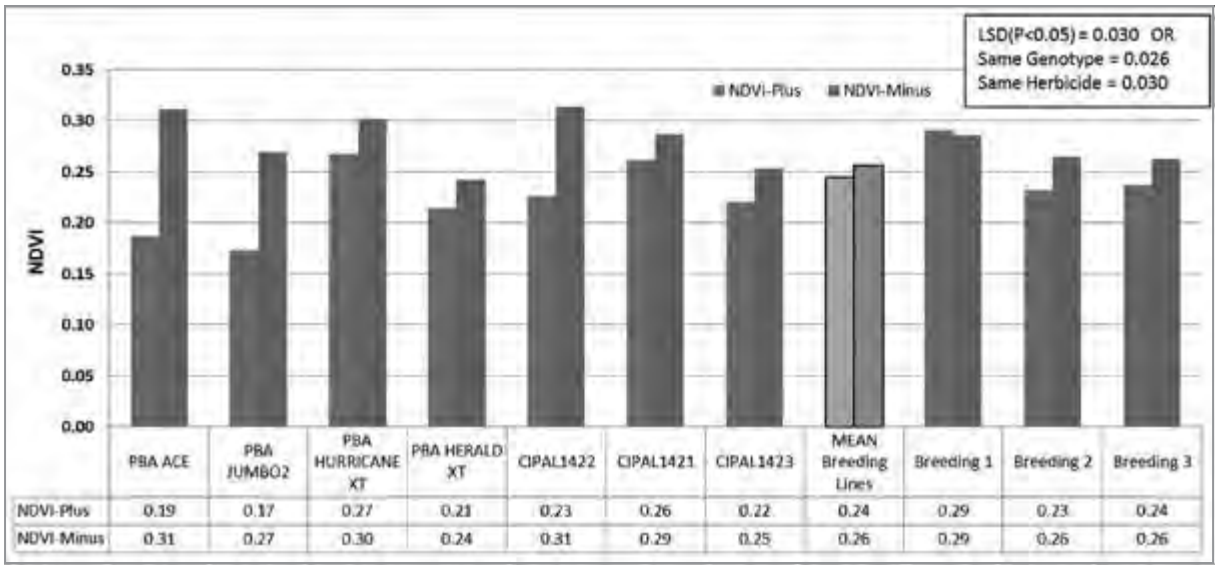


Figure 3. NDVI readings on IMI-susceptible (PBA Ace and PBA Jumbo2) and IMI-tolerant lentil lines (remaining entries) after being treated with 400 g/ha Belta® 700 WG on 22 June at Wagga Wagga in 2014. This figure shows PBA Ace and PBA Jumbo2 to be very susceptible, however the remaining lines show high but varying levels of tolerance.

A subset of three of the highest yielding breeding lines (under IMI-free conditions – Minus) is presented in figures 2, 3 and 4 here as well as the mean of all 47 breeding lines (MEAN Breeding Lines). Breeding 1 had the highest yield in the Plus treatments, excellent IMI tolerance, high NDVI, good standing ability and very early maturity (crop-topping potential) (Table 2). Its Height and Selection scores were, however, below those of PBA Ace and PBA Jumbo2.

Table 2. Maturity, Erect, Height and Selection scores* near maturity of the lentil IMI-tolerant variety trial, Wagga Wagga 2014.

Variety	Maturity		Erect		Height		Selection **	
	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
PBA Ace	8.0	3.9	8.0	5.7	4.7	8.0	2.4	8.0
PBA Jumbo2	7.9	4.2	7.0	6.7	4.7	7.3	1.7	7.0
PBA Hurricane XT	4.3	4.7	7.6	7.6	7.7	7.7	7.6	8.0
PBA Herald XT	4.1	4.5	7.4	6.7	7.0	7.0	7.0	6.3
CIPAL1422	6.3	5.1	7.7	6.6	9.0	8.6	8.9	7.9
CIPAL1421	4.7	3.4	7.0	6.7	7.7	7.9	7.7	7.6
CIPAL1423	4.5	4.1	7.7	7.7	7.0	7.4	8.1	7.4
Breeding 1 ***	2.1	2.4	8.0	8.0	6.0	6.0	6.3	6.4
Breeding 2 ***	3.9	4.5	8.0	7.6	7.0	7.3	7.3	7.7
Breeding 3 ***	4.2	4.3	8.0	8.1	8.0	7.8	7.7	8.1
Mean breeding lines ***	4.5	4.4	7.5	7.4	6.9	7.0	6.7	6.8
l.s.d. (P <0.05)	1.29		0.91		1.12		1.29	

* Scores range from 1 (least expression of the character) to 9 (maximum expression of the character).

** 'Selection' score is a subjective rating of agronomic type including height, erect growth, canopy density and ground cover, pod density and freedom from disease.

** Breeding lines 1, 2 and 3 are the highest yielding of the 47 breeding lines under evaluation, while 'MEAN Breeding Lines' is the mean of all breeding 47 lines.

Acknowledgements

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