Crop-topping and desiccation are valuable tools for weed control in pulses

Eric Armstrong[1], Gerard O'Connor[1], Luke Gaynor[1], Sarah Ellis[1] and Neil Coombes[1]

[1] NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, PMB Pine Gully Road, Wagga Wagga NSW 2650, eric.armstrong@dpi.nsw.gov.au, luke.gaynor@dpi.nsw.gov.au

Abstract
Desiccation is the strategic termination of crop growth using herbicides. Crop-topping is the strategic in-crop application of knock-down herbicides to prevent seed set in weeds. These two operations can be combined to produce a more powerful management tool in pulses to control in-crop weed escapes and to advance harvest. This approach broadens weed management practices for pulses and strengthens their role in crop sequences of southern farming systems. Timing is critical and must be matched to the weed seed development, irrespective of the development stage of the crop. The pulse variety could suffer substantial yield losses if it has not reached physiological maturity at or before the timing of crop-topping/desiccation. Most current pulse varieties are late maturing and unsuited as significant yield losses occur. However, recent advances by Pulse Breeding Australia (PBA) have produced earlier maturing varieties of field pea, faba bean, lentil and lupin, much better suited to crop-topping, with a further array of untapped resources in gene-banks. Field pea has the added advantage of being late sown, thereby extending the pre-sowing window for weed control. Over the past three years at Wagga Wagga, many breeding lines of field pea, faba bean, lentil and lupin have been evaluated. Celine, PBA Pearl and PBA Oura were shown to be the best of the current commercial field pea varieties, but there is potential to further improve these from the vast germplasm available. A spread of application timings was applied to further refine this management tool.

Keywords
Farming systems, crop development, physiological maturity, crop sequences

Introduction
Pulses are an important and expanding component of cropping sequences in southern NSW (Armstrong & Holding 2015). They bring many advantages, particularly biological nitrogen fixation and crop diversification. A research and development priority at Wagga Wagga is to ensure weed control is not compromised during the pulse phase of the crop sequence; particularly as well managed farms in the region have a low tolerance for weed seed bank increases. To their advantage, pulses bring alternative herbicide groups and options, and can be used specifically to target grass weeds, particularly annual ryegrass and wild oats. They can be brown-manured if weed burdens are very high and are also suited to narrow windrow burning weed control in some situations. Peas bring a further advantage of being one of the latest sown crops in the planting calendar, thereby extending the pre-sowing weed control window. However, many pulse varieties are slow growing and compete poorly with weeds during the cooler winter months. Inevitably some weeds escape and set seed in spring. In these situations, crop-topping (Armstrong 2015) becomes a useful tool, ensuring the pulse phase maintains or lowers weed-seed banks.

Timing of the crop-topping/desiccation knock-down herbicide is critical and should be targeted at the milky-dough stage of the weed seed to ensure its sterilisation (McGillion & Storrie 2006). It is essential that development of the pulse variety must have reached or passed its physiological maturity by this time in order to avoid grain damage and associated yield losses. Many current pulse varieties are relatively late maturing (eg. chickpeas, lupins and Kaspa field peas) and therefore unsuited. Given the huge diversity of germplasm for development and maturity across pulse species, there is broad scope for selecting early maturing, high yielding lines specifically suited to crop-topping. Coincidently, many of the more recent varieties developed by Pulse Breeding Australia (PBA) are early, but this is largely a response to the increased frequency of shorter, dry springs over recent times.

This paper reports on preliminary findings of a crop-topping experiment conducted at Wagga Wagga in southern NSW in 2014. This investigation studied a wide range of pulse varieties with diverse phenology and a spread of spray timings from the end of flowering to maturity.

Methods

The trial was sown late (7 June 2014) to widen the pre-seeding weed control window. Eighteen pulse varieties and breeding lines with varying flowering and crop maturities were included. The experiment was set up in a factorial design with "spray times" the main blocks and "pulse varieties and breeding lines" the sub-plots, with all treatments replicated three times. There were four crop-topping spray treatments - one unsprayed (Nil) and three spray timings, each spray spaced approximately one week apart (see Table 1) from post-flowering onwards. The crop-topping chemical used was Gramoxone® (250 g/L paraquat) at 2 L/ha. The trial was sown on the Wagga Wagga Agricultural Institute in southern NSW.

Table 1. Description, timing and crop stage of the 4 crop-topping treatments at Wagga Wagga in 2014.

Treatment	Date	Crop timing of the spray
Nil	Unsprayed control	
Early spray	14 October	A week after most pulse varieties had completed flowering
Mid spray	22 October	Approximately one week before physiological maturity of the earliest finishing pulse variety
Late spray	29 October	After the earliest varieties had reached harvest maturity

The pulse treatments included 16 field pea breeding lines and varieties, one faba bean line and one lentil variety. Ten of the field pea lines, sourced from previous PBA breeding experiments conducted at Wagga Wagga, were selected for early maturity and high yield. The six commercial field pea entries were recent releases and similarly varied widely in maturity. The faba bean breeding line was AFO7175 - reputedly early flowering with early maturity. PBA Hurricane XT is a high yielding imidazolinone tolerant lentil variety.

The dates of crop development, flowering and maturity were recorded on a bi-weekly basis from the first replication of the Nil treatment, as only minor variation was observed across replicates for the same variety. Date of start of flowering was recorded when 20% of plants had their first flower open. Date of end of flowering was recorded when 95% of plants finished flowering (flowers closed, dropped off or desiccated). Date of crop maturity was recorded when all plants had turned brown, ripe and judged ready for mechanical harvest.

The trial was conducted under weed-free conditions using current recommended management and cultural practices. Glyphosate (1.5 L/ha) + Goal® (75ml/ha) were used pre-sowing to control weeds and Terbyne ® (1kg/ha) + Stomp® (2L/ha) were incorporated by sowing for post sowing residual weed control.

Results

The season was characterized by above average early season rainfall (April to July) which recharged soil moisture profiles, but was followed by a very dry and warm July to October period (rainfall 50% below average and mean daily temperatures 2° C above average). Flowering dates reflected normal variety patterns for this area but the dry warm finish hastened the end of flowering and maturity by about 2-3 weeks.

Dates of flowering and maturity of all pulse varieties and breeding lines are presented in Table 2. These dates reflect a wide variation in development stages across variety and breeding lines. Start of flowering varied by up to 28 days across entries but this gap reduced to only 7 days by the end of flowering and 12 days by maturity.

The first crop-topping spray application (14 October) was far too early for all pulse genotypes and yield losses were substantial, ranging from 42-82%. The majority of this yield loss was attributed to reductions in seed size (measured as grams per 100 seeds, ranging from 30-63 %). The commercial variety SW Celine and four breeding lines were least affected at this spray but Kaspa field pea and lentil suffered considerably greater losses. Most genotypes showed no significant yield losses at the last two spray applications (22 and 29 October), suggesting physiological maturity had been reached. Exceptions were PBA Percy, Kaspa, OZP1415, faba bean and lentil, all of which showed consistent yield losses of 11-21% at the second spray and 4-11% at the final spray.

Table 2. Dates of flowering and maturity of 16 field pea varieties and breeding lines, one faba bean variety and one lentil variety when sown on 7 June 2014 at Wagga Wagga NSW.

Variety	Start Flowering	End Flowering	Length of Flowering - days	Crop Maturity
PBA Percy	7 Sep	10 Oct	33	4 Nov
Celine	13 Sep	8 Oct	26	30 Oct
PBA Oura	14 Sep	8 Oct	24	31 Oct
PBA Pearl	17 Sep	10 Oct	23	2 Nov
PBA Wharton	22 Sep	10 Oct	18	2 Nov
Kaspa	27 Sep	10 Oct	13	5 Nov
07H082P005	8 Sep	10 Oct	33	27 Oct
06H461P-4	12 Sep	10 Oct	28	29 Oct
07H467P004	12 Sep	8 Oct	26	29 Oct
08H226-HO09-2	12 Sep	9 Oct	27	29 Oct
07H119P002	13 Sep	10 Oct	27	29 Oct
06H445P-5	13 Sep	8 Oct	25	30 Oct
08H019-HO09-12	15 Sep	8 Oct	24	31 Oct
06H204P-10	15 Sep	9 Oct	24	2 Nov
OZP1415	16 Sep	12 Oct	27	4 Nov
05H278-06HOS2003	23 Sep	8 Oct	15	2 Nov
Faba bean (AFO7125)	31 Aug	8 Oct	38	5 Nov
Lentil (PBA Hurricane XT)	13 Sep	15 Oct	32	8 Nov

Table 3. Grain yield comparisons of 18 pulse varieties and breeding lines allowed to mature naturally (nil spray) compared to crop-topping on 14, 22 and 29 October 2014.

Variety	Grain Yield t/ha				% Yield Loss		
	Nil	14 Oct	22 Oct	29 Oct	14 Oct	22 Oct	29 Oct
SW Celine	2.39	1.35	2.30	2.40	43	4	-1
PBA Percy	2.06	1.05	1.62	1.90	49	21	8
PBA Pearl	2.04	0.96	1.88	2.11	53	8	-4
PBA Oura	2.14	0.98	2.02	2.11	54	6	2
PBA Wharton	2.08	0.75	1.89	2.23	64	9	-7
Kaspa	1.65	0.30	1.39	1.69	82	16	-2
07H082P005	2.13	1.24	2.15	2.28	42	-1	-7
06H445P-5	1.97	1.14	1.97	2.16	42	0	-10
07H119P002	2.03	1.17	2.02	2.14	43	1	-5
07H467P004	1.95	1.11	1.81	1.99	43	7	-2
08H019-HO09-12	1.97	1.03	2.00	2.07	48	-1	-5
06H204P-10	2.27	1.17	2.14	2.43	49	6	-7
08H226-HO09-2	1.87	0.95	1.73	1.89	49	8	-1
06H461P-4	2.11	1.05	2.03	2.28	50	4	-8
05H278-06HOS2003	2.24	1.02	2.07	2.35	55	8	-5
OZP1415	1.89	0.71	1.69	1.99	63	11	-5
Faba bean (AFO7125)	1.74	0.91	1.58	1.55	48	9	11
Lentil (PBA Hurricane XT)	1.56	0.49	1.30	1.49	69	17	4
LSD (P<0.05)	0.190						

Discussion and Conclusions

Our R&D priority for pulses at Wagga Wagga is to demonstrate they can be a reliable and strong component of southern NSW farming systems and ensure they are a viable and profitable phase of crop sequences. Significant advances in varieties have been made by PBA over the past two decades and this has been complemented by well formulated agronomy packages by state agencies, GRDC and agribusiness. However, tight weed control and reductions in the soil weed seed bank in the pulse phase still remains a priority. Crop-topping fits well here, giving pulse farmers a useful weed control strategy to ensure effective management of weeds that may escape conventional control methods.

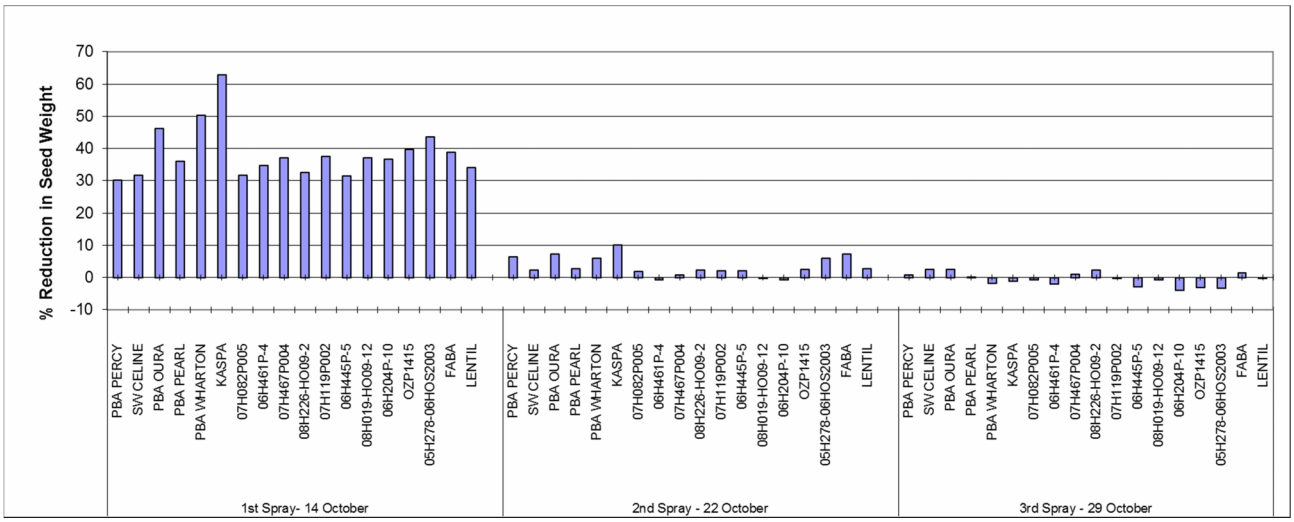

Figure 1. The reduction in seed size of eighteen pulse varieties and breeding lines at Wagga Wagga NSW resulting from three crop-topping sprays on 14 October, 22 October and 29 October 2014.

Field pea was the highest yielding, earliest maturing and best adapted pulse to crop topping within the scope and confines of this experiment at Wagga Wagga in southern NSW. SW Celine was the highest yielding, earliest maturing and best crop-topping treatment. Its yield and seed size was the least affected by the earliest spray (14 October) and unaffected by the last two sprays (22 and 29 Oct). Of the remaining commercial varieties, those best suited to crop-topping were PBA Oura, PBA Pearl and PBA Wharton. Several pea breeding lines also show promise, particularly 07H028P005.

SW Celine is a European bred variety released in Australia 2005 and currently licensed to Nuseed (Anon 2005). It is a semi-dwarf, erect, semi leafless white flowered pea with large, round, creamy-white seeds. Its main feature is its early flowering, early maturity and superior pod set, giving it excellent drought tolerance and yield advantage in dry, quick finishing springs. Unfortunately, the variety does not have the sugar pod type shatter resistance of commercial varieties such as Kaspa, but this feature (as well as other attributes such as disease resistance), could be incorporated through conventional breeding programs in future

Yield and seed size of lentil and faba bean were generally more affected by crop topping than field pea. Only one variety of each was trialled here and future investigations should widen this selection to include earlier flowering and earlier maturing genotypes for different pulse species. Selection of earlier maturing, high yielding pulse varieties suited to crop topping is identified as a valuable breeding objective for southern NSW.

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