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Forage legume break crops in Australia and their tolerance to broadleaf herbicides

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Summary – The intensification of the cropping phase in Australian ley and phased farming systems has lead to a demand for forage legumes that are tolerant or resistant to applied herbicides. The study described here identifies the herbicide tolerance of 12 forage legumes to 10 herbicides. It clearly shows that the cultivars Leeton (*Trifolium resupinatum*) and Antas (*T. subterraneum var. brachycalycinum*) were the most herbicide tolerant of the legumes tested and that Cefalu (*T. vesiculosum*) and Bigbee (*T. alexandrium*) were amongst the most sensitive. However the highest yielding legumes were Zulu (*T. vesiculosum*) and Caprera (*T. incarnatum*). The most phytotoxic herbicides identified were MCPA, Spinnaker and Tigrex while the safest herbicides were Treflan, Stomp, and Yield.

Key-words: forage legume, break crop, herbicide tolerance, herbage yield

Résumé: *L'intensification des systèmes de culture associant céréales et légumineuses a fait émerger la demande pour des légumineuses tolérantes ou résistantes à l'application d'herbicides. 12 espèces ont été confrontées à 10 types d'herbicides. Les cultivars Leeton (*Trifolium resupinatum*) et Antas (*T. subterraneum brachycalycinum*) ont été les plus tolérants alors que Cefalu (*T. vesiculosum *) et Caprera (*T. incarnatum*). Les herbicides identifiés comme les plus phytotoxiques ont été MCPA, Spinnaker et Tigrex alors que les moins nocifs ont été Treflan, Stomp et Yield.*

Mots-clés: *légumineuse fourragère, culture associée, tolérance aux herbicides, rendement*

Introduction

Annual pasture legumes from the Mediterranean region have been used extensively in Australian ley and phased farming systems for over 90 years (Audas, 1921). Their original introduction was accidental although it was not long before the benefits of these legumes were realized. The most common of these naturalized legumes are *Medicago laciniata, M. minima, M. polymorpha, Trifolium glomeratum, T. tomentosum* and *T. subterraneum*. The ability of these legumes to fix atmospheric nitrogen that can be harvested by subsequent crops and their high dietary value made them a valuable component of Australian farming and grazing systems. Subsequently efforts to improve on these naturalized legumes were undertaken. Most of the efforts have focused on *Trifolium subterraneum, T. michelianum, T. resupinatum, T. hirtum, Medicago truncatula, M. polymorpha, M. littoralis, Ornithopus compressus* and *O. sativus*.

In recent times poor commodity prices for wool and more attractive cropping options have shifted the focus towards intensifying the cropping phase. New farming systems have evolved requiring legumes that are able to fix large amounts of nitrogen in a single year between extended cropping sequences. To meet these requirements new plants were selected and released to fulfill these new requirements. The forage legume species currently used include, *T. alexandrinum, T. subterraneum var. brachycalycinum, T. resupinatum, T. michelianum, T. incarnatum* and *T. vesiculosum*. In the year that the forage legume is grown, broadleaf weeds can be a major problem, reducing nitrogen fixation and increasing the weed seed pool which can reduce subsequent crop yields. The major broadleaf weeds in these systems are capeweed (*Arctotheca calendula*), Paterson's curse (*Echium plantagineum*), erodium (*Erodium botrys, E. cicutarium and E. crinitum*), doublegee (*Emax australis*), Indian Mustard (*Brassica juncea*) and wild radish (*Raphanus raphanistrum*) (Anon, 1988). It is often necessary to control these weeds or others in the forage legume break crop.

This paper describes an experiment that compares the early spring herbage production of 12 forage legumes and their tolerance to 10 herbicides (Table 1).

Materials and Methods

The experiment was located near the Agricultural Institute, Wagga Wagga, New South Wales (longitude 147^{0}21'E and latitude 35^{0}03'S, 219 m above sea level) on a red earth soil Gn2. 12 (Northcote 1979). Soil pH tests (0-10 cm) indicated the soil was acid (pH 5.7, 5:1 water or pH 4.7 CaCl) and that the soil phosphorus levels were high (Colwell P test 49 ppm). The herbicides were applied either pre-emergent, 2 days prior to sowing or post-emergent at the 4-5 leaf stage. The experiment was a randomised strip plot design with 2 replications, and plots 1.8 x 3 m long.

Each of the cultivars shown in Table 1 were inoculated and lime pelleted prior to sowing at 12 kg/ha (equal weight of seed) on 14 May 1999 into a prepared seedbed with 300 kg/ha superphosphate (9%P, 12% S) using a cone seeder with 15 cm row spacings.

The ten herbicides (Table 1) were applied across each of the 12 cultivars either on 12 May for the pre-emergent herbicides or 27 July 1999 for the post-emergent herbicides. The water carrier was applied at 100 L/ha using a boom spray with TeeJet 8001E flat fan nozzles at a pressure of 250 kPa.

Table 1. Sown legumes species and cultivars as well as applied herbicides, herbicide rates and concentration of active ingredients.

Forage legume species and cultivars	Herbicides, rates and concentration of active ingredients
Trifolium michelianum	**Pre-emergent herbicides**
cv. Bolta	Treflan applied at 2.0 L/ha
cv. Paradana	trifluralin 400 g/L
T. alexandrinum	Stomp applied at 3.0 L/ha
cv. Bigbee	pendimethalin 330 g/L
cv. Elite II	Yield applied at 2.0 L/ha
T. incarnatum	oryzalin 125 + trifluralin 125 g/L
cv. Caprera	**Post-emergent herbicides**
cv. Contea	Simazine applied at 1.25 L/ha
T. resupinatum	smazine 500 g/L
cv. Leeton	Broadstrike applied at 25 g/ha
cv. Laser	flumetsulam 800 g/kg
T. vesiculosum	Jaguar applied at 750 mls/ha
cv. Zulu	bromoxynil 250 g/L + difufenican 25 g/L
cv. Cefalu	Bromoxynil applied at 1.5 L/ha
T. subterraneum var. brachycalycinum	bromoxynil 200 g/L
cv. Antas	Tigrex applied at 750 mls/ha
Ornithopus sativus	MCPA 250 g/L + difufenican 25 g/L
cv. Cadiz	Spinnaker applied at 300 mls/ha
	imazethapy 240 g/L
	MCPA applied at 1.0 L/ha
	MCPA Amine 500 g/L

Legume plant density was measured by counting seedlings in 2 x 0.5 m rows per plot on 14 July 1999. Herbage yield was estimated by scoring each species using a sliding pointer on a 50 cm ruler. This method is a scoring system that generates normally distributed data. Scores (0 – 50) are recorded in 0.1 increments providing a potential 500 data points. Rule scores for each species were calibrated separately by scoring a representative area (0.4 m^2) in 8 plots that were then cut, dried and weighted. Calibration samples were dried at 70^{0}C for 48 hours to obtain dry weights. Individual regressions for each of the species revealed that Bolta, Paradana, Bigbee, Elite II, Caprera, Contea, Cefalu, Zulu, and Cadiz could be combined in an overall regression as their slopes and intercepts were not significantly different from each other. Their combined regression ($y = y0 + ax + bx^2$) was significant at P=0.001. *T. resupinatum* cultivars Leeton and Laser were combined and fitted to $y = ax^2b$ (P=0.001) and *T. subterraneum var. brachycalycinum* cultivar Antas was fitted to the same regression ($y = ax^2b$, P=0.001). However, it had a slope and intercept significantly different to that fitted for Leeton and Laser.

An analysis of variance model including correction for spatial effects (Gilmore *et al.* 1997) was fitted using Genstat. Significant differences based on lsd values (*P*=0.05) were determined on absolute values and placed against the corresponding figures expressed as % change relative to the Treflan treatment.

Results and discussion

Seedling counts indicate that Antas (88 plants/m^2), had significantly lower plant populations and Paradana had a significantly high plant population (394 plants/m^2) than the other legumes (mean 178 plants/m^2). A low population (<20 plants/m^2) of volunteer weeds, mainly fumitory *(Fumaria spp.)* was also present hence the results presented have been compared to the Treflan treatment as the yield of the unsprayed controls was reduced by weed competition.

The cultivars Leeton and Antas were amongst the most herbicide tolerant forage legumes tested (Table 2). These two cultivars were however out yielded by the cultivars Zulu and Paradana, although the high dry matter yield of Paradana may be in part due to its higher seedling density. Caprera was capable of high herbage production although it was generally more sensitive to the herbicides tested than Zulu or Paradana. Leeton and Cefalu produced the lowest herbage yields and this may explain the apparent higher level of herbicide tolerance of Leeton.

Table 2. Herbage yield (kg/ha) of 12 Forage legumes treated with Treflan and the yield expressed as a percent (%) of the Treflan treatment. Different lower case letters indicate significant differences within cultivars (down each column) (P=0.05).

	Leeton	Antas	Paradana	Bolta	Zulu	Contea
	Herbage yield (kg/ha)					
Treflan	1480 b	2580 ab	3335 ab	3070 a	4026 a	3074 a
	Herbage yield expressed as a percentage of the Treflan treatment (%)					
Stomp	133 a	96 a	107 a	97 a	88 ab	94 ab
Yield	139 a	79 bc	88 a	63 b	81 abc	75 abc
Simazine	85 b	92 ab	52 d	65 b	67 bcd	82 ab
Broadstrike	71 bc	76 bc	61 cd	69 b	78 abc	81 ab
Jaguar	104 b	83 bc	86 ac	80 a	47 d	71 bcd
Bromoxynil	100 b	63 c	60 c	66 b	57 cd	77 abc
Tigrex	67 c	75 bc	77 bcd	77 ab	69 bcd	54 c
Spinnaker	11 d	113 a	77 bcd	86 a	69 bcd	26 e
MCPA	95 b	75 bc	80 bc	70 b	61 cd	47 de

The post-emergent herbicides Tigrex, MCPA and Spinnaker caused the largest yield suppression. The pre-emergent herbicides were the least damaging although this may in part be explained by the additional recovery time they received compared to that of the post-emergent treatments. Stomp and Yield did not reduce the herbage yield of any cultivar except for Stomp applied to Caprera and Bigbee and Yield applied to Bolta and Cefalu. Simazine was most damaging to Paradana but had no impact on Antas. Capera was sensitive to Broadstrike however it caused no yield reduction in Leeton, Antas, Zulu, Contea and Laser. Bromoxynil was best tolerated by the cultivars Cadiz and Leeton, although Cefalu was very sensitive to bromoxynil. Cadiz, Elite II and Bigbee were highly sensitive to Tigrex and MCPA. Spinnaker was tolerated best by Antas and least by Leeton, Contea, Laser and Caprera.

Table 2. continued.

	Laser	Cadiz	Caprera	Elite II	Bigbee	Cefalu
			Herbage yield (kg/ha)			
Treflan	2364 a	3263 a	3925 a	3639 a	3243 a	2971 a
		Herbage yield expressed as a percentage of the Treflan treatment (%)				
Stomp	95 ab	84 abc	66 bc	83 ab	71 bc	86 ab
Yield	92 ab	101 a	91 ab	75 abc	78 ab	57 cd
Simazine	69 bcd	57 d	71 bc	79 ab	59 bc	51 cd
Broadstrike	82 abc	62 bcd	49 c	69 bc	62 bc	64 bcd
Jaguar	62 cd	79 acd	68 bcd	52 cd	50 cd	17 e
Bromoxynil	45 de	113 a	60 cd	57 bc	48 cd	16 e
Tigrex	65 cd	14 e	64 cd	27 de	35 de	52 cd
Spinnaker	19 e	63 cd	18 e	61 bc	62 bc	62 bcd
MCPA	72 bc	27 e	42 de	3 e	19 e	41 de

Conclusion

Annual legumes have for many years formed the basis for ley and phased farming systems in Australia. Recent increases in cropping intensity has demanded new annual legumes (forage legumes) that will exist for 1 year and fix high amount of nitrogen that can be harvested by the subsequent cropping phase. The forage legume year is also expected to be weed free, which often requires the application of herbicides. The herbicides used to control many of the weeds are often phytotoxic to legumes (Dear *et al.*, 1995) and can subsequently reduce herbage yield and nitrogen fixation. A better understanding of the relative tolerance of forage legumes to herbicides can assist in initial species and cultivar selection for sowing and herbicide choice. Through this information losses in nitrogen fixation can be avoided or minimised.

This study has identified that the careful selection of herbicides will be necessary to avoid yield suppression and reduced nitrogen fixation in forage legumes. Further work is also warranted to determine herbicide tolerance levels between cultivars and to select new species/cultivars with improved herbicide tolerance.

References

Audas, J.W. (1921). The true clovers naturalised in Victoria. *Journal Department of Agriculture Victoria,* 19, 650-660.

Anon (1988). Nitrophilous Weeds. In: Slone, Cook and King (Ed.) The Economic impact of pasture weeds, pests & diseases on the Australian Wool Industry. pp 26-35. Sydney: Australian Wool Corporation.

Dear, B.S., Sandral, G.A. and Coombes, N.E. (1995). Differential tolerance of Trifolium subterraneum L. (subterranean clover) cultivars to broadleaf herbicides 1. Herbage yield. *Australian Journal of Experimental Agriculture*, 35, 467-474.