Effect of herbicide treatment on the productivity of some annual pasture legumes

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Summary A range of new annual pasture legume species have been developed for southern Australia in recent years. This paper reports data from a field experiment in Western Australia that examined the effect of 13 herbicide treatments on the growth and seed production of 11 pasture legume cultivars.

There was considerable variation in the tolerance to herbicides amongst the cultivars. Most of the variation was between genera, but differences in tolerance within genera were also apparent. Producers need specific information for each new pasture cultivar as current knowledge for traditional species, such as subterranean clover (*Trifolium subterraneum* L.), cannot be directly transferred. Legume seed yields did not always correlate well with herbage production. There were significant seed yield increases following herbicide treatment for some cultivars, despite substantial reductions in herbage. This is suggested to be a function of increased availability of soil water in spring.

Keywords Pasture, legumes, herbicides, dry matter, seed production.

INTRODUCTION

The management of weeds in annual pasture is a complex and dynamic aspect of farming systems, generally involving a combination of grazing and strategic use of herbicides.

In the past, wheatbelt pasture legumes in Western Australian were mainly subterranean clover and species of annual medics (*Medicago* spp.) which had the ability to persist through cropping phases and self-regenerate. More recently, farming systems have changed with increasing emphasis on strategic short term pastures now referred to as 'phase farming'

Table 1. Effect of 12 herbicide treatments on the percentage change in dry matter production and seed yields (SY) of burr medic and subterranean clover cultivars relative to the unsprayed control in 1999. Dry matter assessed in August and September. Days to 10% flower given in parenthesis. Values within columns (back-transformed) followed by the same letter are not significantly different at P = 0.05.

Species	Burr medic Santiago (67)			Subterranean clover Dalkeith (86)			Subterranean clover Urana (95)		
Herbicide (Rate ha^{-1})	Dry matter Aug	Dry matter Sept	SY	Dry matter Aug	Dry matter Sept	SY	Dry matter Aug	Dry matter Sept	SY
Pre-sowing									
Treflan 1.5 L	-15 a	-41 bc	-38 bc	-28 b	-33 b	-7 a	-31 b	-22 a	7 a
Post-emergence (*6 leaf of legume*)									
Glyphosate 400 mL	-35 c	-40 bc	-34 bc	-43 cd	-61 c	-26 a	-50 cd	-60 de	-17 a
Paraquat 500 mL	-81 e	-53 c	-50 c	-56 d	-55 c	-14 a	-63 de	-53 bcd	14 a
Simazine 750 mL	-4 a	-21 b	-40 bc	-8 a	-26 b	-28 a	-11 a	-19 a	-7 a
MCPA (amine) 1 L	-42 c	-67 d	-43 c	-31 b	-54 c	-28 a	-34 b	-57 bc	-48 a
Bromoxynil 1.5 L	-86 e	-68 d	-70 d	-38 bc	-56 c	-31 b	-76 f	-72 e	-73 b
Jaguar 500 mL	-70 d	-69 d	-47 c	-33 b	-58 c	-36 b	-70 ef	-68 c	-71 b
Tigrex 400 mL	-38	-53 c	-23 b	-15 a	-25 b	-15 a	-27 b	-38 b	-23 a
Broadstrike 25 g	-13 a	-12	-14 a	-10 a	-27 b	-4 a	-15 a	-9 a	0 a
Spinnaker 250 mL	-17 b	-30 b	-37 bc	-9 a	-22 a	-14 a	-10 a	4 a	37 a
Diuron 200 + 2,4-DB 400 mL	-19 b	-41 bc	-35 bc	-15 a	-44 bc	-34 b	-40 bc	-49 b	-2 a
Spray-top									
Paraquat 500 mL			-59 d			-29 a			-29 a
Dry matter (t ha^{-1}) or seed yield (kg ha^{-1}) – unsprayed	1.1 a	6.1 a	1434 a	1.1 a	8.1 a	1597 a	1.1 a	6.5 a	499 a

(Reeves and Ewing 1993). Plant characteristics for annual phase pasture species are quite different from traditional self-regenerating species and this has led to a major refocusing of pasture species breeding and selection in recent years (Howieson *et al*. 2000). A large number of new annual pasture legume species and cultivars have now been released for Australian agriculture. These include species like, yellow serradella (*Ornithopus compressus* L.), French serradella (*O. sativus* Brot.), biserrula (*Biserrula pelecinus* L.) and gland clover (*T. glanduliferum* L.).

There is little information about the management of these new species in the context of weed control, particularly in relation to the phytotoxicity of herbicides. The effect of herbicide treatment on the dry matter production and seed production of a range of pasture legumes was examined in a field experiment in the absence of grazing.

MATERIALS AND METHODS

The experiment was established at Goomalling, Western Australia (31.35°S, 116.85°E) in 1999 on a sandy loam pH ($CaCl_2$) 4.8 at the surface. There were 11 pasture legume cultivars sown in three replicate blocks in plot sizes of 2.2 × 46 m. The cultivars included subterranean clover cvv. Dalkeith and Urana, burr medic cv. Santiago, French serradella cv. Cadiz, yellow serradella cv. Charano, Persian clover (*T. resupinatum* L.) cv. Persian Prolific, balansa clover (*T. michelianum* Savi.) cvv. Frontier and Paradana, arrowleaf clover (*T. vesiculosum* Savi.) cv. Cefalu, biserrula cv. Casbah and gland clover cv. Prima. The pastures were sown at a rate of 25 kg ha^{-1} on 10 June after a knockdown herbicide in May. The experiment was ungrazed and plots were maintained in a weed-free condition to avoid confounding weed competition with herbicide reaction.

Thirteen herbicide treatments (including an untreated control) were applied in a cross-plot design, randomised between replicates and with a spray width of 3 m. The treatments included a pre-sowing application of Treflan™ and post-emergent applications (3 August – 6-leaf stage of legume) of Broadstrike™, Jaguar™, Tigrex™, Spinnaker™, MCPA, simazine, 2,4-DB + diuron, bromoxynil, glyphosate and paraquat. Paraquat was also applied as a spray-topping treatment on 23 September. Plots were visually rated in August and September for effects on herbage production with appropriate calibration cuts. Seed yields were measured in December by harvesting 2 × 0.2 m^2 quadrats per plot with a suction harvester, before threshing to extract

Table 2. Effect of 12 herbicide treatments on the percentage change in dry matter production and seed yields (SY) of serradella and biserrula cultivars relative to the unsprayed control in 1999. Dry matter assessed in August and September. Days to 10% flower given in parenthesis. Values within columns (back-transformed) followed by the same letter are not significantly different at P = 0.05.

Species	Yellow serradella Charano (89)			French serradella Cadiz (97)			Biserrula Casbah (102)		
Herbicide (Rate ha^{-1})	Dry matter Aug	Dry matter Sept	SY	Dry matter Aug	Dry matter Sept	SY	Dry matter Aug	Dry matter Sept	SY
Pre-sowing									
Treflan 1.5 L	-14 a	-26 b	-13 a	-10 a	15 a	-48 b	-12 a	-1 a	125 b
Post-emergence (*6 leaf of legume*)									
Glyphosate 400 mL	-56 c	-88 f	-27 a	-51 c	-81 d	-36 a	-75 c	-86 d	11 a
Paraquat 500 mL	-47 bc	-46 bc	-7 a	-48 c	-30 bc	-47 b	-94 d	-97 e	-57 b
Simazine 750 mL	-10 a	-31 b	-14 a	-6 a	-17 a	-21 a	-2 a	-17 a	64 b
MCPA (amine) 1 L	-45 b	-82 ef	-52 b	-25 b	-68 d	-64 b	-29 b	-70 c	41 a
Bromoxynil 1.5 L	-18 a	-28 b	-31 a	-10 a	-5 a	-1 a	-20 a	-30 b	79 b
Jaguar 500 mL	-35 b	-61 cd	-16 a	-24 b	-43 c	-36 a	-16 a	-37 b	92 b
Tigrex 400 mL	-30 b	-70 de	-41 b	-24 b	-44 c	-37 a	-36 b	-50 bc	101 b
Broadstrike 25 g	-10 a	-18 a	-1 a	-3 a	3 a	-38 a	-43 b	-95 e	-86 c
Spinnaker 250 mL	-17 a	-23 a	2 a	-3 a	-1 a	-29 a	-32 b	-38 b	83 b
Diuron 200 + 2,4-DB 400 mL	-17 a	-33 b	-44 b	-18 a	-21 ab	-57 b	-21 b	-58 c	51 a
Spray-top									
Paraquat 500 mL			-29 a			-42 a			-33 a
Dry matter (t ha^{-1}) or seed yield (kg ha^{-1}) – unsprayed	1.1 a	7.1 a	1073 a	1.1 a	6.4 a	782 a	1.0 a	6.4 a	642 a

clean seed. Data was spatially analysed using REML in Genstat V after square-root transformation.

RESULTS AND DISCUSSION

All cultivars established well except Urana subterranean clover and this was reflected in its poor seed production. Reactions to herbicides varied widely between species. (Tables 1–4). Treflan resulted in some thinning of plant numbers (particularly the clover species) but had no serious impact in any species. Glyphosate severely reduced herbage production in all species but favourable growing conditions in spring allowed seed production to be maintained at high levels. Paraquat was more damaging than glyphosate in burr medic and was particularly severe for biserrula and gland clover. The balansa clovers showed a strong capacity to recover after mid-winter paraquat application but seed yields appear to be considerably reduced with its use as a spray-topping treatment. The effectiveness of simazine on this loam soil type was difficult to quantify but Persian clover and arrowleaf clover showed particular sensitivity. All cultivars were damaged by MCPA although seed production was acceptable for most of the clover species. Burr medic and most of the clover species showed a substantial reduction in herbage production following either bromoxynil or Jaguar (especially Persian clover, arrowleaf clover and Urana subterranean clover). Tigrex generally had less impact on herbage growth, with Dalkeith subterranean clover and both balansa clovers showing strong recovery. Developing pasture legume cultivars that are tolerant to phenoxy-based herbicides is desirable in order to capitalise on the spray-graze technique for weed control, which is low cost and presently under-utilised.

The serradellas and biserrula were sensitive to both Jaguar and Tigrex but were considerably more tolerant of bromoxynil. Bromoxynil may provide a useful alternative in these species for broadleaf weed control, especially where capeweed is a problem or where an alternative to Group B herbicides is required. Broadstrike and Spinnaker were generally safe across all species except biserrula. Dear and Sandral (1999) also reported a low level of phytotoxicity of Spinnaker on subterranean clover. Mixtures of Diuron and 2,4-DB caused moderate levels of damage, particularly in biserrula and the clover species.

In some instances, particularly for later maturing cultivars such as Paradana and Casbah, seed production responded positively to herbicide treatment despite substantial losses in herbage production. This is consistent

Table 3. Effect of 12 herbicide treatments on the percentage change in dry matter production and seed yields (SY) of balansa and Persian clover cultivars relative to the unsprayed control in 1999. Dry matter assessed in August and September. Days to 10% flower given in parenthesis. Values within columns (back-transformed) followed by the same letter are not significantly different at P = 0.05.

Species	Balansa clover Paradana (108)			Balansa clover Frontier (78)			Persian clover Prolific (99)		
Herbicide (Rate ha^{-1})	Dry matter Aug	Dry matter Sept	SY	Dry matter Aug	Dry matter Sept	SY	Dry matter Aug	Dry matter Sept	SY
Pre-sowing									
Treflan 1.5 L	-36 bc	-34 b	45 a	-34 bc	-20 a	8 a	-19 a	-5 a	89 b
Post-emergence (*6 leaf of legume*)									
Glyphosate 400 mL	-51 cd	-74 c	28 a	-64 e	-79 c	-2 a	-68 c	-70 c	40 a
Paraquat 500 mL	-44 cd	-39 b	19 a	-52 de	-36 b	9 a	-64 c	-39 b	47 a
Simazine 750 mL	-3 a	-37 b	19 a	-3 a	-25 a	-13 a	-16 a	-38 b	37 a
MCPA (amine) 1 L	-35 bc	-37 b	18 a	-51 de	-41 b	-3 a	-46 b	-48 b	52 a
Bromoxynil 1.5 L	-51 cd	-41 b	-2 a	-51 de	-50 b	-40 b	-79 d	-70 c	24 a
Jaguar 500 mL	-57 d	-43 b	18 a	-45 cd	-42 b	10 a	-72 cd	-64 c	31 a
Tigrex 400 mL	-28 b	-19 a	39 a	-22 b	-10 a	-23 a	-37 b	-14 a	31 a
Broadstrike 25 g	-12 a	-13 a	31 a	-14 a	-14 a	-21 a	-17 a	14 a	29 a
Spinnaker 250 mL	-24 b	-11 a	6 a	-23 b	-13 a	43 b	-31 b	8 a	34 a
Diuron 200 + 2,4-DB 400 mL	-29 b	-28 b	-3 a	-20 a	-17 a	-27 a	-44 b	-40 b	41 a
Spray-top									
Paraquat 500 mL			6 a			-59 b			6 a
Dry matter (t ha^{-1}) or seed yield (kg ha^{-1}) – unsprayed	1.1 a	6.6 a	753 a	1.1 a	6.6 a	944 a	1.1 a	5.2 a	394 a

with the observations of Dear and Sandral (1999) who found positive seed yield responses in weed-free subterranean clover of up to 92%. They attributed this response to the conservation of soil water when growth is suppressed, which is subsequently used during flowering and seed filling. The large seed yield responses in Persian clover in this experiment appear somewhat of an artefact of unexplainably low seed yields in the untreated control plots.

The effect of spray-topping on seed production will be influenced by the stage of maturity of the pasture. Santiago, Dalkeith and Frontier balansa clover had begun to flower four to five weeks before spraying. Charano, Cadiz, Prolific, Casbah and gland clover had been flowering for one to two weeks before spraying. Paradana and Cefalu had yet to flower. Given its early maturity, the substantial reduction in seed yield of Frontier after spray-topping is surprising, but may have been a consequence of a reduced capacity for regrowth after spraying.

Table 4. Effect of 12 herbicide treatments on the percentage change in dry matter production and seed yields (SY) of arrowleaf and gland clover cultivars relative to the unsprayed control in 1999. Dry matter assessed in August and September. Days to 10% flower given in parenthesis. Values within columns (back-transformed) followed by the same letter are not significantly different at P = 0.05.

Species	Arrowleaf clover			Gland clover		
	Cefalu (120)			Prima (95)		
Herbicide (Rate ha^{-1})	Dry matter		SY	Dry matter		SY
	Aug	Sept		Aug	Sept	
			Pre-sowing			
Treflan 1.5 L	-18 a	-23 a	10 a	-26 b	-32 b	-25 a
			Post-emergence (*6 leaf of legume*)			
Glyphosate 400 mL	-43 bc	-74 c	-10 a	-75 e	-84 d	-44 b
Paraquat 500 mL	-62 cde	-57 bc	-16 a	-95 f	-89 d	-80 c
Simazine 750 mL	-16 a	-47 b	-4 a	-10 a	-33 b	-20 a
MCPA (amine) 1 L	-38 b	-46 b	-6 a	-59 cd	-39 bc	-8 a
Bromoxynil 1.5 L	-72 e	-73 c	-42 b	-61 d	-56 c	-13 a
Jaguar 500 mL	-58 cd	-71 c	-37 a	-57 cd	-81 d	-21 a
Tigrex 400 mL	-26 b	-22 a	-24 a	-44 c	-45 bc	-1 a
Broadstrike 25 g	3 a	-9 a	2 a	-7 a	-11 a	-32 a
Spinnaker 250 mL	-17 a	-21 a	-8 a	-21 a	-17 a	-10 a
Diuron 200 + 2,4-DB 400 mL	-34 b	-61 bc	-20 a	-46 c	-42 bc	-17 a
			Spray-top			
Paraquat 500 mL			-35 a			-66 bc
Dry matter (t ha^{-1}) or seed yield (kg ha^{-1}) – unsprayed	1.1 a	6.9 a	721 a	1.1 a	6.7 a	1155 a

CONCLUSION

Producers need to be aware that there is considerable variation amongst new pasture legume species in their tolerance to commonly used herbicides. Current knowledge about tolerance in subterranean clover cannot be directly transferred to the new species. Although most species appear to have several options which can be used with safety, many of these are costly (in excess of $15 ha^{-1}), limiting their use to seed crops. Higher priority needs to be given to the screening of herbicide tolerance in pasture breeding and selection programs in order to develop cultivars tolerant of low cost herbicides.

Seed production following herbicide treatment does not always reflect the substantial reductions in herbage production. The positive yield responses reported in this paper are probably a consequence of conserved soil water, no defoliation and favourable growing conditions in spring. Plant responses are likely to be modified by soil type and seasonal variation as well as the timing of herbicide application and grazing intensity. Further research is needed to address these issues.

ACKNOWLEDGMENTS

The GRDC and Australian Wool Innovation provided financial support through the National Annual Pasture Legume Improvement Project. I thank Ian Rose and Steve Bell who provided excellent technical assistance, Ben Brasher who conducted the statistical analysis and Mr. R. Leeming who provided farmland for the experiment.

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