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Demographic responses to the chemical control of Doublegee

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EXPERIMENTAL SUMMARY 1989

1. Demographic responses to the chemical control of Doublegee (Emex australis)

2. Competitive effect and response of Emex australis in a grazed annual pasture (Paper).

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1.1 Control of Doublegee in Medic pasture (88WH47 5455EX)

Objectives

To assess the effects of pre-emergence and post-emergence applications of herbicides upon survival and seed production by Doublegee. To measure dry matter production of all species in relation to herbicide treatments.

Experimental

The experiment, now in its second year, took place within a Wongan Hills pasture sown to medic (cv. Santiago) at 8 kg/Ha in 1988. Using a plant plotter, co-ordinates were taken of all Doublegee seedlings within a known area. Three quadrats were established per treatment. Visits were made at fortnightly intervals in order to census the plants. Herbage cuts were made on August 22 1989.These consisted of three 250 x 250 mm quadrats per replicate and were sorted according to species; dried and weighed. The size of the seedbank was estimated (for each treatment) by taking 17 samples at random per plot (100 mm diameter x 100mm depth) on 5 July 1989. Seed production within the demographic quadrats was measured by harvesting stems and crowns of all plants on 3 October 1989. Throughout the experiment, the pasture was stocked at 5.5 d.s.e./Ha

Results

The was a good deal of difference in the responses to Pursuit pre-emergence and post-emergence between the 1988 and 1989 seasons. The effectiveness of these two treatments is reversed from the 1988 results (Table 1.1). The Diuron 2,4-DB treatment has still worked reasonably well and while the percentage reduction in numbers was not as good as 1988, seed production was still similar.

Table 1.1. Effect of chemical treatments upon Doublegee survival

Treatment type		Herbicide	Rate of application (ml/Ha)	Initial density (plants/m^2)	Percentage reduction in population
Pre-em	'88	Pursuit	250	571	21.5
	'89			500	3.2
Post-em	'88	Diuron +	200 +	498	76.0
	'89	2,4-DB	750	126	15.1
	'88	Pursuit	250	659	13.3
	'89			365	55.3
Control	'88			532,532	0.0,0.8*
	'89			309,309	1.1,9.1

* For control, first and second figures relate to periods during which pre-emergence and post-emergence herbicides were active, respectively

Because of the differing effects of Pursuit the herbage composition varied dramatically from 1988. The pre-emergence treatment produced 30% more Doublegee dry matter than the control. However the legume dry matter component was up by almost 400% . Grass dominance appeared in all treatments except the Pursuit pre-emergence where the grass dry matter component was actually down 5%.(Table 1.2)

Table 1.2. Composition of herbage harvested on August 22 1989

Treatment type		Herbicide	DM (g/m^2) Doublegee	Legumes	Grasses	Other	Total
Pre-em	'88	Pursuit	27.25	97.99	15.85	9.03	150.12
	'89		94.62	390.88	14.95	2.60	503.05
Post-em							
	'88	Diuron +	16.91	68.85	38.63	29.31	153.70
	'89	2,4-DB	30.52	95.11	234.64	23.12	383.39
	'88	Pursuit	43.55	78.15	26.06	1.17	148.93
	'89		17.99	258.01	151.28	7.30	434.58
Control							
	'88		43.69	75.96	35.51	1.87	157.03
	'89		61.36	139.22	192.94	12.69	406.21

Seed bank figures for the different treatments reflect the success or otherwise of the 1988 treatments. Seedling densities for 1989 were down in all treatments except the Pursuit pre-emergence. This treatment had the highest percentage of viable seed bank emergence 12% better than the 1988 result (Table 1.3).

Table 1.3. Characteristics of residual seedbank of Doublegee

Treatment type	Density of seeds (N°/m^2) 0 - 100 mm	Average seedling density (N°/m^2)	Percentage of viable seed bank emerged
Pre-em Pursuit	1475	500	33.9
Post-em Diuron + 2,4-DB	1624	126	7.7
Pursuit	2899	365	12.6
Control	2072	309	14.9
1988 Whole site	1946	542	21.8

Only the Pursuit post-em had any effect on the reproductive fate of Doublegee with only 30.9% of emerged plants surviving through to set seed. The lack of chemical effect in 1989 was possibly due to the range of growth stages at the time of spraying (Table 1.4).

Table 1.4. Effect of chemical treatment on reproductive fates of Doublegee plants

Treatment type	Herbicide	Probability of reproduction		Range in time to production of first seed (d)	
		'88	'89	'88	'89
Pre-em	Pursuit	0.538	0.698	82-110	61-132
Post-em	Diuron + 2,4-DB	0.151	0.605	97-131	89-146
	Pursuit	0.621	0.309	82-131	89-132
Control		0.776	0.835	82-131	76-146

Doublegee seed production also varied from treatment to treatment with Pursuit pre-emergence producing more seed than the control. This probably relates to the lack of grass competition within the Pursuit pre-emergence plots (Table 1.5).

Table 1.1.5. Effect of herbicides on Doublegee seed production

Treatment type	Herbicide	Seed production (N^o/m^2)		Change in seed production (%)	
		'88	'89	'88	'89
Pre-em	Pursuit	315	2570	-89.0	+7.6
Post-em	Diuron + 2,4-DB	899	938	-68.6	-60.7
	Pursuit	2483	1006	-13.4	-57.8
Control		2867	2389	0.0	0.0

COMPETITIVE EFFECT AND RESPONSE OF *EMEX AUSTRALIS* IN A GRAZED ANNUAL PASTURE

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Summary. Competitive relationships of *Emex australis, Trifolium subterraneum* and *Hordeum glaucum* were investigated experimentally using a neighbourhood design in a grazed pasture. Neighbourhoods of *Emex* had the smallest effect upon target plants of *Trifolium* and *Hordeum* (competitive effect), but of the three species, *Emex* targets suffered the greatest reductions in growth when grown in mixtures (competitive response). Since *Emex* was the least competitive species, we suggest that a) its impact in rotations could be reduced by sowing desirable plants into sparse first-year pastures and b) the effect of a biocontrol agent for *Emex* might be greatly enhanced in a competitive environment.

INTRODUCTION

Emex australis Steinh. (henceforth *Emex*) is a major annual weed of pasture/crop rotations in southern Australia (Gilbey and Weiss 1980). One of its major adaptations to this form of land management is an ability to accumulate large seed banks; seeds can survive for more than four years either on the soil surface or when buried (Cheam 1987). While a number of herbicides provide effective control of *Emex* in wheat and grain lupin crops, seed production is prodigious in the sparse pastures which follow cropping sequences, in part owing to the absence of a reliable selective herbicide for controlling *Emex* in pastures (Gilbey 1976). Without effective control, enough seeds can be produced during the first year of pasture to ensure the predominance of *Emex* throughout the remainder of the rotation (Gilbey 1976; Gilbey and Lightfoot 1979). One possible method for damping this seed production cycle would be to resow the annual grasses and legumes whose seed banks are progressively depleted during the cropping phase of the rotation (Reeves 1987; Taylor and Ewing 1988). The success of this approach would depend largely upon the relative competitiveness of *Emex*, particularly under conditions of grazing. This paper describes the competitive relationships between *Emex* and two other annuals (*Trifolium subterraneum* L. and *Hordeum glaucum* Steud., henceforth *Trifolium* and *Hordeum*) in a pasture naturally dominated by these species and grazed by sheep.

METHODS

The study was conducted in a fifth-year pasture, set stocked at 5 D.S.E./ha, on a sandy loam soil at Wongan Hills Research Station (approximately 200 km north-east of Perth). On 27 April 1989, two weeks after the first germination flush of the growing season, an area 24x24 m was cultivated to a depth of 5 cm. Seeds of either *Emex, Trifolium* or *Hordeum* were then hand broadcast along single 8x24 m subplots and lightly incorporated.

Competitive relationships within individual species and in pairwise combinations of the three species were investigated with a neighbourhood design described by Goldberg and Werner (1983). Individual neighbourhoods were established on 17 May 1989. For both single species and pairwise combinations, PVC rings (15 cm diameter and 2 cm deep) were centred upon a nominated target individual, pressed into the ground and anchored with tent pegs. Neighbouring plants were thinned so that either 0, 2, 4, 8 or 12 individuals remained, corresponding to total (including target plant) densities of 56, 157, 278, 501 and 723 plants/m^2. Three replicates were set up at each density.

Top growth of target and neighbour plants was harvested on 29 September 1989. Following oven-drying, weights were obtained of the target plants and the combined neighbours from each neighbourhood. Target plant performance was assessed over the range of density and biomass of each neighbour species by fitting linear regressions to transformed ($\log_{10}$ and square root) data. Competitive effects were compared among neighbour species by utilizing a *t*-test for slopes of the linear regressions. A second method for comparing the competitive effects among neighbour species and competitive responses among target species consisted of averaging the target plant weight of a species over all non-zero neighbour densities, then expressing this average as a percentage of the mean value for isolated (competition-free) plants.

RESULTS AND DISCUSSION

While both log and square root transformations succeeded in linearizing the data, the latter transformation almost always yielded higher r^2 values for fitted regressions. When reciprocal comparisons of competitive effect were made within pairs of species, only two significant differences were detected. One was the greater (t = 1.82; df = 24; P = 0.05) slope of the regression of *Emex* target biomass on *Hordeum* neighbour density, compared to the regression fitted to *Hordeum* target biomass on *Emex* neighbour density (Fig. 1). This difference indicated that *Hordeum* had a greater per individual competitive effect on the target than did *Emex*. The second significant difference lay in the reciprocal comparisons between *Emex* and *Trifolium*, where the latter species had a greater (t = 2.79; df = 26; P = 0.005) per gram competitive effect (Fig. 2). However, this difference may have been an artefact of the method of sampling; had roots been harvested as well, the disparity between the ranges of total neighbour biomass for *Trifolium* and *Emex* (Fig. 2) might have been smaller.

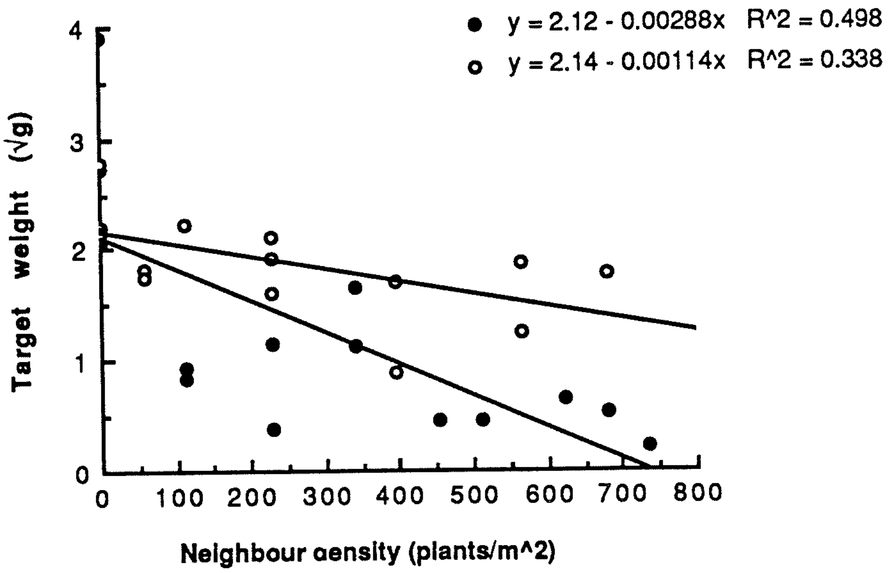

Figure 1. Regressions of target plant biomass on neighbour density. (●) *Emex* target, *Hordeum* neighbour, (○) *Hordeum* target, *Emex* neighbour.

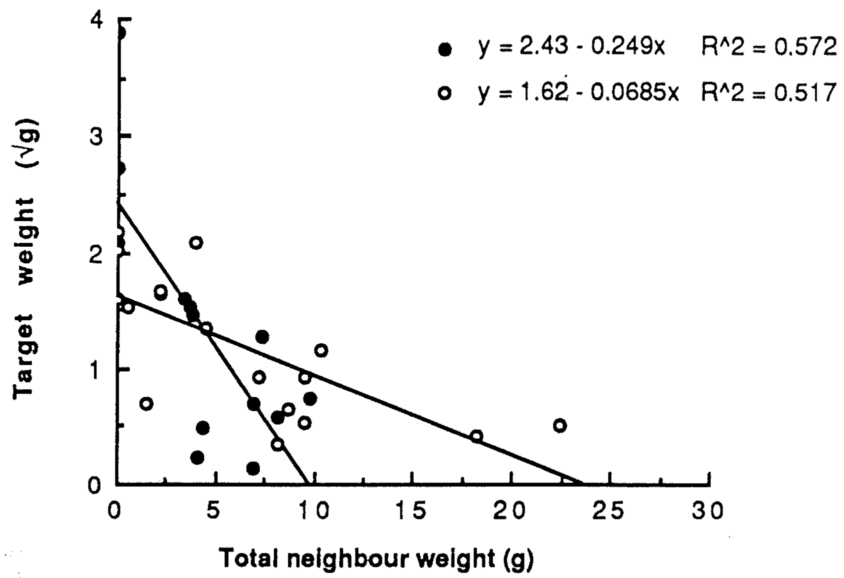

Figure 2. Regressions of target plant biomass on total neighbour biomass. (●) *Emex* target, *Trifolium* neighbour, (○) *Trifolium* target, *Emex* neighbour.

When target weights were expressed as percentages of the mean weights of isolated plants, a significant overall competitive effect (rows) was detected only in the case where *Hordeum* was grown with various neighbour species. The rankings of the three neighbours in relation to the reduction of target weight were generally in the order of *Hordeum* > *Trifolium* > *Emex* (Table 1). All competitive responses (columns) were highly significant (P = 0.01). The rankings of the three species in terms of competitive response were *Emex* > *Trifolium* > *Hordeum*. Thus the rankings of competitive effects and responses were complementary; *Emex* showed the weakest effect and the strongest response.

Table 1. Comparison of competitive effects among neighbour species and competitive responses among target species averaged over all neighbour densities > 0. For each target species, weight is expressed as a percentage of the mean value for isolated plants. Values are means ± s.e. For within-column comparisons (among targets), values with the same letters are not significantly different by a Mann-Whitney *U*-test (P = 0.05).
* P = 0.05; ** P = 0.01.

Target species	Neighbour species: *Emex*	*Trifolium*	*Hordeum*	Kruskall-Wallis X^2 (d.f. = 2)
Emex	19.5±6.32[a]	13.1±3.61[a]	8.25±2.64[a]	2.43[ns]
Trifolium	32.5±9.24[ab]	20.5±3.15[ab]	15.0±3.44[b]	2.38[ns]
Hordeum	53.2±6.13[b]	33.2±3.90[b]	38.9±13.7[c]	8.35*
Kruskall-Wallis X^2 (d.f. = 2)	9.27**	10.8**	12.3**	

The competitive rankings of these three species could be expected to be affected by the degree to which they were grazed. Detailed measurements of the defoliation of *Emex* indicated that approximately 80% of marked plants were defoliated between 4-8 weeks following emergence. However, only 30% of leaves on offer were removed at the time of heaviest grazing and levels of leaf removal dropped markedly as the season progressed (Panetta and Randall, unpublished data). While the degree of defoliation of *Trifolium* could not be distinguished from that of *Emex* on the basis of casual observation, *Hordeum* individuals appeared to be defoliated severely and regularly, especially in the early part of the growing season. Hence the species which was most heavily grazed was also the one which exhibited the greatest competitive effect and least competitive response (Table 1).

The results from this study suggest that the impact of *Emex* within pasture/crop rotations could be lessened by sowing mixtures of grass and legume seed into otherwise sparse first-year pastures. Since *Emex* is a relatively weak competitor, not only is its seed production decreased in the presence of other pasture species (Panetta and Randall, unpublished data), but the implementation of biological control would appear most feasible in a competitive environment (Burdon et al. 1981). Owing to certain undesirable characteristics of *Hordeum* spp., further assessment of the relative competitiveness of other annual grasses, in particular *Lolium rigidum*, is required.

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