THE EFFECTS OF PACLOBUTRAZOL ON SEED YIELD COMPONENTS OF TRIFOLIUM SUBTERRANEUM

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ABSTRACT
Paclobutrazol was sprayed at a rate of 1 kg a.i./ha at and prior to flowering on swards of *Trifolium subterraneum* L. cv. Dalkeith over two years (1992 and 1993). There was no consistent effect of paclobutrazol on seed yield. Only at the earliest spraying time (20 days before flowering) in 1992 was there a significant increase in yield. Paclobutrazol increased burr and seed number for all spraying times in both years. However, the general absence of a yield response was due to a decrease in seed size in both years. The ratio of surface to buried seed yield and number (measured in 1992) increased with application of paclobutrazol. In fact, most of the increase in seed number was in the surface component. These results are discussed with respect to other paclobutrazol studies and commercial seed production.

KEYWORDS
Paclobutrazol, *Trifolium subterraneum*, seed, yield components

INTRODUCTION
Paclobutrazol has been used on a range of legume herbage species to examine effects on seed production. In some cases paclobutrazol has increased yield (e.g. Li and Hill 1989; Hampton 1991; Askarian *et al*. 1994) and in other cases not (e.g. Marshall and Hides 1986). Of the seed yield components, paclobutrazol when applied at an appropriate stage of crop development, will increase inflorescence production but has variable effects on other yield components eg. florets per inflorescence, seed per floret etc. For *Trifolium subterraneum*, an annual legume, the results may differ from those obtained in perennial legume species used in previous studies as the flowering period can be much shorter. Apart from possible increases in potential yield, commercial harvesting of seed from *T. subterraneum* could be enhanced by inhibiting burr burial. Part of the ecological success of *T. subterraneum* is related to its ability to bury burr. In commercial seed production recovering this component of yield is only possible after repeated operations that disturb the top 5 cm of soil. This leads to high costs and may leave the soil more exposed to erosion. There is a possibility that burr burial could be reduced by the paclobutrazol through its ability to inhibit peduncle elongation if applied at the appropriate stage. In this study, paclobutazol was applied to field plots of *T. subterraneum* to examine the effects on seed yield and its components.

MATERIALS AND METHODS
Field trials were conducted in two successive years (1992/3) at the Agricultural Research Institute near Wagga Wagga in southern New South Wales on a red-brown earth with pH (0.01 M CaCl2) of 4.8 (0-10 cm) and soil P (Olson) of 22 mg/g. The trials were not irrigated or grazed. The experiment was sown in both years at 65 kg/ha, a rate which simulates a regenerating stand. Seed was sown into a prepared seed bed with 300 kg/ha of Mo-superphosphate (0.04% Mo, 9.5% P). The timing of the crop operations is given in Table 1. The cultivar Dalkeith was chosen for its early maturity minimising possible interactions between yield, its components and length of growing season. Three spraying times (Table 1) were replicated four times in a randomised complete block design. The unsprayed control occurred three times within each block. Plot size was 1.8 x 6 m with 0.5 m buffer between plots. Date of flowering (T3) was predicted from a model described by Archer *et al*. (1987) and earlier sprays were applied approximately 20 (T_1) and 10 (T_2) days before flowering (Table 1).

In both years one harvest only was taken at maturity. In 1992, two samples (each 0.1 x 1 m) were taken from each plot. The samples were divided into surface and buried components by removing the surface dry matter and burr and then hand cultivating down to 5 cm and suction harvesting the buried component. These samples were cleaned and threshed and number of seed and total seed weight were measured. Two further quadrats (0.25 m^2 to a depth of 5 cm) were used to measure plant density, runners per plant and number of burrs. Number of runners was approximated by counting all runners that had initiated within a lateral distance of 2.5 cm from the taproot. In 1993 only the latter quadrats were sampled.

Data was analysed using Genstat V 5.3. The box-cox procedure was used to test for normality and where necessary data was transformed to achieve approximately normal distributions. Results are presented as untransformed means but levels of significance are derived from transformed data.

RESULTS AND DISCUSSION
The effect of paclobutrazol on yield was not consistent over years (Table 2). In 1992 spraying at T_1 significantly increased yield but not at the later spraying times. In 1993 paclobutrazol had no effect on yield. However, in both years there were significant effects on seed yield components. Paclobutrazol increased the number of seed and burr considerably in both years but decreased the seed size. Less consistent were the effects on runner number and plant density. In 1992 runner number and plant density increased only at T_2 whereas in 1993 there was an increase in runner number and plant density regardless of time of application.

In 1992 seed yield, number and size were measured on samples taken from the surface and buried to 5 cm. Paclobutrazol application increased the seed yield and seed number from the surface component relative to the buried component (Table 3). Paclobutrazol decreased seed size equally in buried and surface components.

These results indicate that the effects of paclobutrazol on seed yield components were more consistent than on yield itself. In both years burr and seed number were increased by paclobutrazol and this was counterbalanced by a decreased seed size, leaving no clear change in seed yield. These results differ with those found in some perennial legume crops where seed size either increased or was unaffected in *Trifolium repens*, *Medicago sativa* or *Lotus uliginosus* (Hampton, 1991; Marshall and Hides, 1991; Tabora and Hill, 1992; Askarian *et al*., 1994). In one year Budhianto *et al*. (1994) did report a decrease in seed size in *T. repens*. In these studies paclobutrazol generally increased the number of harvestable inflorescences and in some cases, this led to an increase in yield. However, the magnitude and significance of these effects depended on year and cultivar. In the present study, the observed increase in inflorescence production (ie. burr number) is consistent with the effects on perennial legumes species. While there was an increase in seed number, the decrease in seed size may have been due to either competition for assimilates, as suggested by Budhianto *et al*. (1994), or direct effects of paclobutrazol on seed growth processes.

One intriguing feature of the results is greater yield in 1993 compared with 1992, despite a much later sowing date in 1993. The most likely explanation for the higher yields in 1993 is that there was a prolonged period of cooler than average weather from September to November allowing ideal conditions for seed production.

Depending on cultivar, season and level of defoliation *T. subterraneum* can bury a high proportion of burr (Rossiter 1961; Walton, 1975) making seed harvest difficult. Paclobutrazol reduced the proportion of unburied seed (dry weight and number, Table 3). In 1992, the increase in seed number was due to extra seed formed on the surface. This may have commercial application especially in situations where harvesting buried seeds is environmentally damaging. However, either reduced spray rates and/or earlier spraying times will have to be examined in order to decrease the effect on seed size.

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Table 1
Sowing, application and harvesting dates.

	1992	1993
Sowing Date	20 May	5 July
Application dates		
T1	25 August	4 September
T2	2 September	16 September
T3 (5% flowering)	14 September	29 September
Harvest	14 January 1993	21 December

Table 2
Seed yield components from control and treated plots. Where there are no means for each spraying time, no significant effect of spraying time was found. Raw means are presented but significant differences ($P < 0.05$) derived in some cases from transformed data. Means followed by different letters are significantly different.

	Yield ($g.m^{-2}$)	Seed No. (m^{-2})	Seed size (mg)	Burr No. (m^{-2})	Runner No. (m^{-2})	Plant density (m-2)
1992						
Control	133^{bc}	14631^{a}	9.09^{a}	5321^{b}	1521^{a}	456^{b}
T_1	163^{a}				1534^{a}	382^{b}
T_2	144^{ab}	***18412^{b}***	***7.57^{b}***	***6643^{a}***	***2731^{b}***	***663^{a}***
T_3	114^{c}				2003^{ab}	466^{b}
1993						
Control	205.8	20952^{b}	9.80^{a}	9215^{b}	1741^{b}	317^{b}
T1						
T2	***211.8***	***26879^{a}***	***7.87^{b}***	***12303^{a}***	***2173^{a}***	***373^{a}***
T3						

Table 3
Effect of paclobutrazol on yield, seed number and seed size from surface (S) or buried (B) samples. Sprayed treatments were meaned across time of application. Data presented are raw means but significant differences (*, $P < 0.05$) are derived from transformed data.

	Yield (g.m-2)			Seed Number (m-2)			Seed Size (mg)		
	S	B	S/B	S	B	S/B	S	B	S/B
Control	70.5*	63.0*	1.12*	7796*	6955	1.12*	9.02*	8.86*	1.02
Sprayed	92.4	47.7	1.94	12023	6390	1.88	7.66	7.33	1.04