PACLOBUTRAZOL SEED TREATMENTS: POTENTIAL FOR RETARDING GROWTH OF FIELD BEAN, RADISH AND PERENNIAL RYEGRASS

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SUMMARY

The feasibility of seed treatments for the application of the growth retardant paclobutrazol to three plant species was investigated. The germination of field bean (*Vicia faba* L.) and perennial ryegrass (*Lolium perenne* L.) was unaffected by 2 h or continuous exposure to paclobutrazol applied in solution at 0, 10 and 100 ppm. Germination of radish (*Raphanus sativus* L.) seed was significantly reduced by paclobutrazol treatments. Seedling emergence of field bean was delayed after 6 h exposure and reduced after 9 h exposure to 100 ppm paclobutrazol. Stem height measurements 40 days after sowing indicated that immersing field bean seed in 1000 ppm paclobutrazol for 3, 6 or 9 h retarded plant growth while 100 ppm treatments had no effect.

INTRODUCTION

Paclobutrazol is a synthetic plant growth regulator which increases seed yield in field bean (Attiya 1985; Attiya *et al* 1983) and perennial ryegrass (Hampton and Hebblethwaite 1984), and root yield in radish (J.N. Gallagher pers. comm.). Field experiments using paclobutrazol as a foliar spray have resulted in yield increases of 9-40% in field bean (Attiya 1985). The yield increases were associated with reduced vegetative growth and attributed to improved flower set and pod retention. The latter effects were associated with a decrease in sink competition by stems associated with a reduction in internode length.

In fruit orchards applications of paclobutrazol to foliage and subsequent leaching (Tukey 1986) or direct applications to soil (Elfving and Proctor 1986) may result in long term soil activity. Paclobutrazol is relatively immobile in soil, binding reversibly to soil colloids (Lever 1986). Its half-life in the soil ranges from 9 to 96 weeks depending on soil type, resulting in lingering retardant effects and a potential for large accumulations in soil, when annual applications are made (Tukey 1986).

In a cropping situation such long term residual effects would be undesirable and would impose severe limitations on crop rotations. Hence other methods of applying paclobutrazol such as soil banding or seed treatments may be appropriate. This paper outlines preliminary investigations into the effect of paclobutrazol seed treatments on three plant species.

MATERIALS AND METHODS

Germination experiment:

Seed of three species, field bean (*Vicia faba* L. cv. Maris Bead), perennial ryegrass (*Lolium perenne* L. cv. Grasslands Nui) and radish (*Raphanus sativus* c. White Icicle) was surface sterilised in 0.3% sodium hydrochlorite solution for 5 minutes, rinsed in water, then immersed in a paclobutrazol solution (0, 10 or 100 ppm) for 2 h. Seed was germinated on moistened filter paper in petri dishes, in an incubator at 25°C in the dark. For continuous exposure treatments the filter paper was moistened with paclobutrazol solutions at concentrations consistent with those in which the seed had been soaked. For the 2 h exposure treatments the filter paper was moistened with distilled water. Germination counts were made at 2-3 day intervals for 10 days following application.

Proc. 40th N.Z. Weed and Pest Control Conf.

Emergence experiment:

Three concentrations of paclobutrazol (0, 100 and 1000 ppm), with four immersion periods (0, 3, 6 and 9 h) were applied to unsterilised field bean seed. After soaking in the specified solutions the seed was blotted dry then left to air dry for 5 days prior to sowing. The seed was sown at the rate of 5 seeds per pot (15 cm diameter), in a 1:1 medium of potting mix and Wakanui silt loam. Pots were placed in a controlled environment cabinet maintained at 20/15 °C, day/night temperature, with a 16 h photoperiod, 75% relative humidity and a PPFD of 300 $\mu\text{mol m}^{-2} \text{s}^{-1}$. Emergence counts were made daily. Fifteen days after sowing plants were thinned to a single plant and plants were harvested 40 days after sowing, when stem height was measured.

Both experiments were completely randomised block designs and the results were analysed using the Genstat statistical package.

RESULTS AND DISCUSSION**Germination experiment:**

Soaking field bean and ryegrass seed in paclobutrazol solutions of 10 and 100 ppm for 2 h or continuous exposure (10 days) did not significantly reduce germination (Table 1).

Paclobutrazol is known to inhibit gibberellin biosynthesis (Dalziel and Lawrence 1984) and the role of gibberellin in seed germination has long been recognized (Jones and MacMillan 1984). The reasons why germination of field bean and ryegrass seed was unaffected (Table 1) are not clear. It is likely that the paclobutrazol did not reach the seed embryo and hence did not interfere with gibberellin synthesis and germination. Differential uptake whereby water permeated the seed coat and embryo before paclobutrazol, triggering gibberellin synthesis and therefore germination is a possible explanation.

TABLE 1: Mean percentage germination of field bean, radish and perennial ryegrass seed immersed in paclobutrazol solutions for 2 h or exposed continuously (C) during germination.

Species	Exposure time	Paclobutrazol concentration (ppm)					
		0		10		100	
		2 h	C	2 h	C	2 h	C
field bean		93	98	95	96	94	90
radish		95	98	92	87	87	78
ryegrass		82	86	88	84	90	83
		C.V. = 6.8%			S.E.M. = 3.0		

Radish seed germination was reduced by the paclobutrazol treatments (Table 1) suggesting that, between species, differences in seed coat permeability or susceptibility to gibberellin biosynthesis inhibition by paclobutrazol occurs. Radish germination has been shown to be more sensitive to paclobutrazol seed soaks than wheat (*Triticum aestivum* L.) seed (Devlin and Koszanski 1985) but no explanation was offered for these differences.

Emergence experiment:

Emergence of field bean for each of the 1000 ppm paclobutrazol treatments are presented in Figure 1.

There were no differences ($P > 0.05$) in emergence rate between any of the distilled water treatments or the 100 ppm paclobutrazol seed treatments. For each of these treatments the final emergence exceeded 90%. Emergence was delayed in the 6 and 9 h 1000 ppm seed treatments and in the 9 h 1000 ppm treatment final emergence at 15 days after sowing was reduced by more than 20%. It is likely that emergence was delayed because paclobutrazol entered the seed reducing the rate of gibberellin synthesis and increasing the time needed for production of sufficient gibberellin to trigger germination and emergence. The reduction in emergence resulting from the 9 h 1000 ppm paclobutrazol treatment suggested that insufficient gibberellin was synthesised to trigger germination. Rate of emergence may also have been reduced in the 6 and 9 h

Fig. 1: Percentage of seedlings emerged from seed treated in 1000 ppm paclobutrazol for four immersion periods.

Fig. 2: Stem height of field bean plants grown from seed treated with three concentrations of paclobutrazol and for four immersion times.

treatments due to a retardant effect of paclobutrazol on shoot growth, resulting in an increased time for shoots to reach the soil surface. Gibberellin is an essential plant hormone for stem extension (Evans 1984) and the observed delay in emergence may directly reflect the effect of paclobutrazol on gibberellin synthesis and subsequent cell division and expansion.

The effects of the paclobutrazol seed treatments on stem height, measured at harvest, 40 days after sowing, are presented in Figure 2. No differences ($P > 0.05$) were recorded for stem height between the 0 and 100 ppm paclobutrazol treatments. Stem height was reduced by each of the 1000 ppm treatments with the extent of reduction increasing with the length of seed immersion (Figure 2).

The reduction in stem height by the 3 h 1000 ppm treatment was associated with a reduction in internode length, while the 6 and 9 h 1000 ppm treatments caused reductions in both internode length and node number. Mean internode length was reduced by 29 and 34% for the 6 and 9 h 1000 ppm treatments respectively, while mean node number was reduced by 14 and 17%. Previous work with paclobutrazol on field beans has shown that plant height was decreased by foliar applications of paclobutrazol (Attiya 1985). This reduction in plant height resulted from shortened stem internodes and was associated with an increase in yield due to increased flower set and pod retention. The reduction in node number recorded in the present study for 6 and 9 h 1000 ppm treatments could possibly affect flower set adversely if the reduction in node number was carried through to maturity.

CONCLUSIONS

Paclobutrazol seed treatments did not adversely affect germination of field beans except at the highest rate and longest exposure tested, 1000 ppm for 9 h. Radish seed germination was more sensitive to the paclobutrazol seed treatments suggesting that species would need to be tested individually before this means of application could be employed.

Stem height reductions recorded 40 days after sowing treated field bean seed suggest that seed treatments are a feasible means of inducing retardant effects. Further work is necessary to determine whether this effect would carry through to maturity and to determine the effects of the treatments on final seed yield.

Although soaking seed in paclobutrazol is a fairly crude method of application, the success of these treatments suggests that further work on external seed applications, possibly including seed pelleting, is warranted.

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