Pertanika J. Trop. Agric. Sci. **25(2)**: 143 - 147 (2002)

ISSN: 1511-3701

Effects of Paclobutrazol and Daminozide on the Growth of *Acacia mangium* Seedlings

SHEIKH ALI ABOD & SULAIMAN YASIN

Faculty of Forestry
Universiti Putra Malaysia, 43400 UPM, Serdang,
Selangor, Malaysia

Keywords: Paclobutrazol, daminozide,* Acacia mangium, *growth control

ABSTRAK

Anak benih A. mangium *berumur 12 minggu telah diberikan semburan daun dengan paklobutrazol dan daminozid pada kepekatan-kepekatan yang rendah iaitu 0, 5, 10 dan 15 mgl^{-1} pada tiga kekerapan semburan yang berlainan iaitu 1 (minggu 0), 2 (minggu 4 & 6) dan 3 (minggu 0, 4 & 6). Setiap bahan kimia itu didapati berkesan untuk merencatkan tumbesaran tetapi paklobutrazol lebih berkesan daripada daminozid. Paklobutrazol pada kepekatan yang terendah iaitu 5 mgl^{-1} pada 1 semburan didapati cukup untuk merencatkan tumbesaran ketinggian dengan berbanding daminozid yang memerlukan kepekatan minima 10 mgl^{-1} dan 2 kali kekerapan semburan. Pada amnya, kesan kedua-dua bahan kimia itu bertambah dengan pertambahan kepekatan dan kekerapan semburan.*

ABSTRACT

Low concentrations of paclobutrazol and daminozide at 0, 5, 10 and 15 mgl^{-1} were foliar sprayed on 12 week old A. mangium *seedlings at three different frequencies of application i.e. 1 (week 0), 2 (week 0 & 4) and 3 (week 0, 4 & 6). Either chemical was effective in controlling growth but paclobutrazol was more potent than daminozide. A low concentration of 5 mgl^{-1} paclobutrazol at 1 application was sufficient to cause a significant reduction in height growth compared to daminozide which required a minimum concentration of 10 mgl^{-1} with 2 applications. In general, the main effects of the chemicals increased with increasing concentration and frequency of spray.*

INTRODUCTION

Malaysia has a total of 171,292 hectares of forest plantation as of October 1996 (Abod 1998). About 80% of the species planted are *Acacia mangium* Willd mainly because of its rapid growth rate. The species have been reported to have a mean annual increment exceeding 30 m^3 ha^{-1} yr^{-1} (Johari and Chin 1986). In the nursery, however, excessive growth of *A. mangium* is a liability if transplanting in the field is delayed. Delays in transplanting often occur when the timing of the site preparation which requires a dry season cannot be synchronized with field planting which requires a wet season. This can result in overgrown seedlings which are more difficult to transport and plant and have been reported to have a poor survival rate because of unfavourable root to shoot ratio, resulting in desiccation after field planting (Abod and Abun 1991).

Researchers have sought reliable, effective and safe methods of controlling shoot growth of tree species using chemical growth retardants. Paclobutrazol (cultar) and daminozide (alar) are two common growth regulators which inhibit endogenous gibberellin biosynthesis and thereby control excessive growth of plants. Daminozide was introduced as a plant growth retardant by Riddel *et al.* (1962) and has since been used extensively for controlling excessive growth in the nursery (Stahly and Williams 1967). Paclobutrazol is relatively new and has been reported to be a reliable, effective and safe chemical for reducing the shoot extension of many temperate trees (Richardson and Quinlan 1986).

Previous studies by Abod and co-workers on the effects of paclobutrazol (Abod and Jeng 1993) and daminozide (Abod and Yap 1994) on the growth of *A. mangium* seedlings tested high chemical concentrations ranging from 25 to 1200 mgl^{-1} foliar sprayed once at week 0. Plants treated with paclobutrazol did not recover in height growth even 12 weeks after treatment at all the concentrations tested. Low concentrations (25 mgl^{-1}) of daminozide, however, were less effective in retarding growth when the plants were sprayed once. The present study tests the effects of lower concentrations of paclobutrazol and daminozide applied at different frequencies of spray on the growth of *A. mangium* seedlings.

MATERIALS AND METHODS

A. mangium seeds were obtained from a plantation in Setul, Negeri Sembilan. The seeds were pre-treated in boiling water for 30 seconds, soaked in tap water for 24 hours and then germinated in a greenhouse. Four weeks after germination, each seedling was transplanted into a black polythene bag measuring 14 cm in diameter and 19 cm in height. The potting medium was a mixture of soil, sand and peat in a ratio of 7:3:2. All plants were given adequate water and nutrients throughout the duration of the experiment. The experiment was conducted in a greenhouse. Plants were selected 12 weeks after germination. Seedlings with uniform shape and measuring 25 cm tall were chosen from a large number of available plants.

Paclobutrazol (PP333) was supplied by Imperial Chemical Industries (ICI) in an aqueous suspension at a concentration of 250 g l^{-1} with an active ingredient of 22.0% ww^{-1}. Its trade name is cultar and chemical formula (2 RS, 3 RS)-1-(4 chlorophenyl) -4, 4 dimethyl-2(1H-1,2,4 triazol-1-yl)pentan-3-o1).

Daminozide (B-9) was supplied in a powder form with an active ingredient of 85.0% ww^{-1}. It is manufactured by Uniroyal Chemical Inc. Middlebury CT 067, USA. Its trade name is alar and chemical formula N-dimethylamino succinamic acid (IUPAC) butanedioic acid mono (2, 2-dimethyl-hydrazide) (CA) succinic acid 2, 2- dimethylhydrazide.

The chemicals were diluted in distilled water to give concentrations of 0, 5, 10 and 15 mgl^{-1} paclobutrazol or daminozide. A surfactant was added at a concentration of 2.0 ml l^{-1}. The aerial parts of plants were sprayed to runoff using a hand-held pressure sprayer. Some of the chemicals were inevitably also deposited in the potting medium.

Three frequencies of application i.e. at week 0 (1 frequency), weeks 0 and 6 (2 frequencies), and weeks 0, 4 and 6 (3 frequencies) were tested for each chemical. There were 15 replicates per treatment totalling 360 plants inclusive of controls. Increment in height (i.e. length of the main stem from the soil surface to the shoot apex) were measured at weekly intervals until harvest, 12 weeks after the first spray. At harvest, plants were measured for dry weights of root, shoot, total plant and the root to shoot ratio. The experiment followed a completely randomized design. All data were subjected to the analysis of variance to test differences between treatment means.

RESULTS

Factorial analysis of the results in Table 1 revealed paclobutrazol to be more effective than daminozide in reducing the height increment and dry weights of the root, shoot and total plant, and increasing the root to shoot ratio of *A. mangium* seedlings. However the results were statistically significant only for height, root dry weight and root to shoot ratio. The effects of the chemicals increased significantly with increasing concentration or frequency of spray (Table 1; *Figs. 1a, b* & c and *2a, b* & *c*). There were, however, statistically significant ($P<0.05$) interactions between chemical x conc. and chemical x frequency of spray for height increment, total plant dry weight and root to shoot ratio. Interactions between conc. x frequency were statistically significant ($P<0.05$) for height, root and shoot dry weight. The interactions between chemical x conc. x frequency were significant for all the parameters measured. The simple effects of paclobutrazol and daminozide on the height increment are presented in *Figs. 1* and *2* respectively.

Low concentrations of daminozide when applied at 1 frequency of spray at week 0 were not effective in controlling the height growth of *A. mangium* seedlings (*Fig. 2a*). A second application at week 6 however became effective for concentrations of 10 and 15 mgl^{-1} (*Fig. 2b*) whereas three frequencies of spray at weeks 0, 4 and 6 caused the lowest concentration of 5 mgl^{-1} to be significantly effective (*Fig. 2c*).

TABLE 1
Main effects of paclobutrazol and daminozide on the growth of *Acacia mangium* seedlings 12 weeks after treatment

Factor		Height increment (cm)	Total root dry weight(g)	Total shoot dry weight (g)	Total plant dry weight (g)	Total root dry weight Ln Total shoot dry weght
Paclobutrazol		7.1	3.08	4.87	7.95	-0.45 (0.64)
Daminozide		12.2	3.26	5.22	8.48	-0.47 (0.62)
Sed		0.39	0.15	0.17	0.24	0.020
F-Test		***	**	ns	ns	*
Control	0	15.5	3.53	6.25	9.78	-0.57 (0.56)
Concentration	5	12.1	3.27	5.47	6.78	-0.51 (0.59)
in	10	10.2	3.19	5.34	8.53	-0.51 (0.59)
(mgl^{-1})	15	8.7	3.10	5.02	8.12	-0.48 (0.61)
Sed		0.55	0.32	0.24	0.34	0.028
F-Test		***	***	**	**	**
Frequency of	1	12.9	3.33	5.65	8.93	-0.52 (0.59)
spray	2	10.8	3.27	5.29	8.56	-0.48 (0.61)
	3	8.3	2.29	4.71	7.69	-0.45 (0.63)
Sed		0.48	0.12	0.21	0.29	0.024
F-Test		***	**	**	*	ns

Error df = 336
Df = 23
Sed = standard error difference

*p<0.05 **p<0.01 ***p<0.001
ns = not significant
Bracketed means are retransformed values

All concentrations of paclobutrazol effectively reduced the height growth of *A. mangium* seedlings. Increasing the frequency of application had a minimal added effect in reducing the growth even for the lowest concentration of 5 mgl^{-1} (*Figs. 1, b & c*).

Paclobutrazol was more immediate than daminozide in controlling the height growth. For example, at 10 mgl^{-1} concentration, differences between the control and paclobutrazol treated plants became statistically significant at week 4 (*Fig. 1b*) compared to at week 6 for daminozide treated plants (*Fig. 2b*). Only a second spray of daminozide at this concentration ensured a continued growth reduction subsequently (*Figs. 2a & b*). There was no recovery in height growth for all paclobutrazol treated plants at harvest 12 weeks after the first spray (*Figs. 1a, b & c*). In contrast, daminozide treated plants exhibited clear signs of recovery particularly at the lower concentrations and frequency of spray (*Figs. 2b & c*).

DISCUSSION

Both paclobutrazol and daminozide reduced the root and shoot growth of *A. mangium* seedlings. Paclobutrazol was more potent than daminozide in reducing all the growth parameters measured. The reduction in shoot growth was greater than the root which in theory should also improve plant water relations and post-transplanting success (Abod and Webster 1989). Paclobutrazol treated plants had a higher root to shoot ratio than daminozide. Increasing the chemical concentration or number of spray applications of paclobutrazol and daminozide resulted in greater reduction in height increment and dry matter production of the seedlings.

The differences in height growth between the treated and control plants increased with time after application for both chemicals. A low concentration of 5 mgl^{-1} paclobutrazol at one application was found to be adequate to retard the height growth of *A. mangium* seedlings by more than 60% of the control at harvest, at week 12 (*Fig. 1a*). However, at least 10 mgl^{-1} daminozide applied twice at weeks 0 and 6 was needed to achieve a similar growth reduction at harvest (*Fig. 2b*). Unlike daminozide, increasing the concentration and frequency of spray of paclobutrazol did not significantly change the magnitude of the reduction in height growth.

Growth inhibition from foliar application of the chemicals in this study may have resulted from the absorption by the young stems and leaves as well as by the roots (since the pot soil

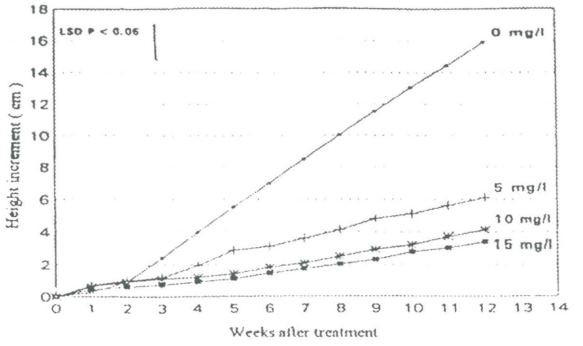

Fig. 1a: Effects of concentration of paclobutrazol on the height increment of A. mangium seedling at frequency of spray at week 0

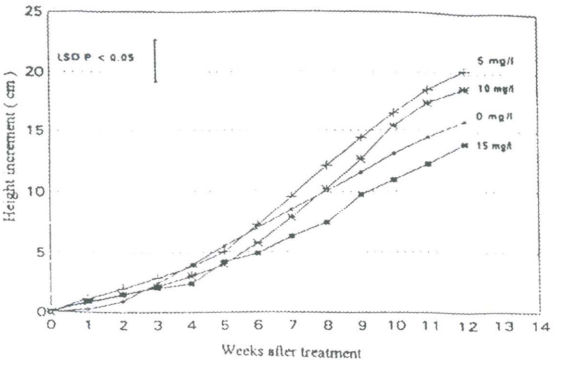

Fig. 2a: Effects of concentration of daminozide on the height increment of A. mangium seedling at frequency of spray at week 0

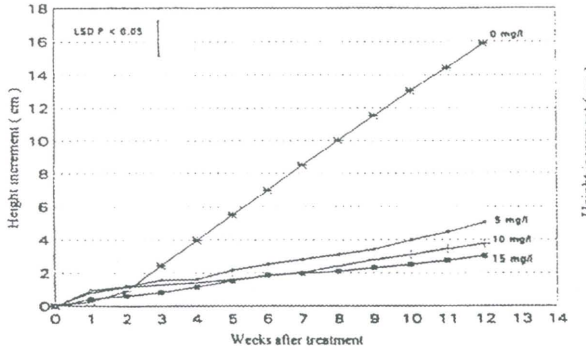

Fig. 1b: Effects of concentration of paclobutrazol on the height increment of A. mangium seedling at 2 frequency of spray at week 0 and 6

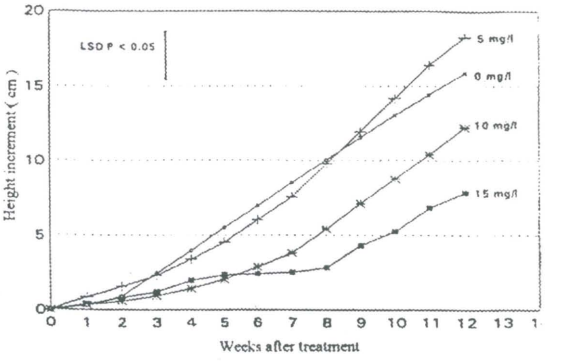

Fig. 2b: Effects of concentration of daminozide on the height increment of A. mangium seedling at 2 frequency of spray at week 0 and 6

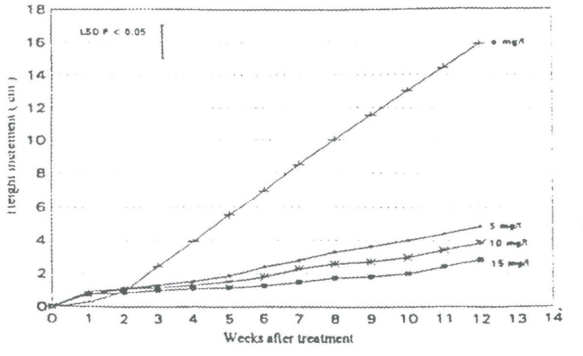

Fig. 1c: Effects of concentration of paclobutrazol on the height increment of A. mangium seedling at 3 frequency of spray at week 0, 4 and 8

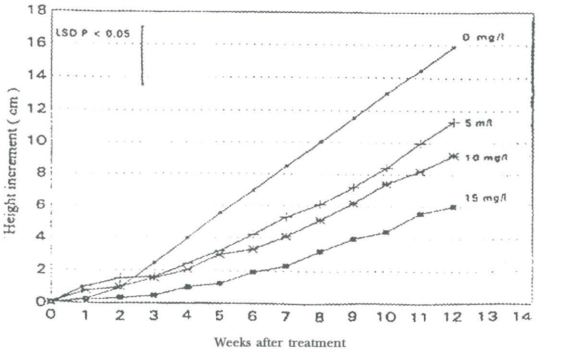

Fig. 2c: Effects of concentration of daminozide on the height increment of A. mangium seedling at 3 frequency of spray at week 0, 4 and 8

was deliberately not covered during application to simulate the actual practice in the nursery) with the subsequent acropetal translocation to the meristematic areas of plant organs (Richardson and Quinlan 1986). It appears that the uptake and translocation of the chemicals at the second and subsequent spray additively act together with the remaining compounds from the previous application to ensure a greater growth reduction. This is clearly demonstrated in the effect of daminozide on the height increment (*Figs. 2a, b & c*). For paclobutrazol, however, it is likely that the additive effect of the chemical may prolong the time for complete recovery in the height growth.

Both paclobutrazol and daminozide appear to have a potential in controlling the growth of *A. mangium* seedlings. The choice of chemical, concentration and frequency of application will depend on the desired magnitude and duration of growth reduction required.

REFERENCES

ABOD, S.A. 1998. Development of forest plantations in Malaysia. A country report. Paper presented to *Asian Productivity Organization Multi-Country Study Mission on Afforestation and Forest Tree Breeding,* 4-13 March, Tokyo Japan.

ABOD, S.A. and J. ABUN. 1991. Root and shoot growth and their manipulations of *Acacia mangium* seedlings. In *Proc. of a Regional Symposium on Recent Developments in Tree Plantation of Humid/Subhumid Tropics of Asia* ed. Sheikh Ali Abod. p. 253-261. June 5-9, 1989, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia.

ABOD, S.A. and L.T. JENG. 1993. Effects of paclobutrazol and its method of application on the growth and transpiration of *A. mangium* seedlings. *Pertanika (Journal of Tropical Agricultural Science)* **16(2)** : 143-150.

ABOD, S.A. and A.D. WEBSTER. 1989. Root and shoot growth of newly-transplanted apple trees as affected by root stock cultivar, defoliation and time after transplanting. *Journal of Horticultural Science* **64(6)** : 655-666.

ABOD, S.A. and S.W. YAP. 1994. Effects of two different growth regulators on the growth and water relations of *A. mangium* seedlings. *J. Trop. For. Sci.* **6(4)** : 489-501.

JOHARI BAHARUDDIN and T.Y. CHIN. 1986. Review of plantation experiences in Peninsular Malaysia. In *9th Malaysian Forestry Conference,* 13-20 October. Sarawak.

RICHARDSON, P.J and J.D. QUINLAN. 1986. Uptake and translocation of paclobutrazol by shoots of M.26 apple rootstock. *Plant Growth Regulators.* **4**: 347-356.

RIDELL, J.A., H.A. HAGEMAN, C.M.J. ANTHONY and W.L. HUBBARD. 1962. Retardation of plant growth by a new group of chemicals. *Science* : 136-391.

STAHYL, E.A and M.W. WILLIAMS. 1967. Size control of nursery tree with N-dimethylamino succinamic acid. In *Proceedings of American Socity for Horticultural Science* **91**:792-794.

(Received: 3 July 2001)
(Accepted: 10 April 2002)