GROWTH PERFORMANCE OF *HOPEA ODORATA* SEEDLINGS IN THE FIELD FOLLOWING TREATMENT WITH PACLOBUTRAZOL

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The supply of high quality planting material for *Hopea odorata,* which belongs to the family Dipterocarpaceae, is limited by its behaviour as an erratic seed bearer. In addition, this species produces recalcitrant seeds. At best, conventional storage methods can only maintain the viability of the seeds for a few weeks. Storage of the seedlings at a slow growth phase has recently been one of the options to provide planting stock on a continuous basis (Tsan *et al.* 1996, Kamaluddin 1998, Krishnapillay *et al.* 1998, Tsan 2000). One of the approaches attempted to achieve this purpose is by the application of paclobutrazol, a gibberellin biosynthesis inhibitor.

Paclobutrazol has been reported to be effective in controlling the growth of a wide range of angiosperms (Williams 1982, DeJong & Doyle 1984, Quinlan & Richardson 1984, Wood 1984, Sterret 1985, Abod 1988, Cheong 1989, Ling 1990, Abod & Jeng 1993, Abod & Cheong 1994, Abod & Yap 1994). The reduction of internode length and altered growth in the leaves are the most pronounced consequences following the application of this growth regulator. At recommended dosages, however, paclobutrazol only inhibited the growth of the shoots without affecting the roots (Tsan 2000). For the dipterocarp species, preliminary studies conducted at the Forest Research Institute Malaysia (FRIM) for the past few years recently revealed that this growth regulator could also maintain the seedlings of a number of species within manageable heights for periods of up to two years (Tsan *et al.* 1997, Tsan 2000, Tsan & Ang 2000). *Hopea odorata* seedlings treated with paclobutrazol at rates of up to 8 g l^{-1} even showed controlled growth in stem diameter when compared with the untreated control seedlings.

The ability of the treated seedlings to recover and gain rapid growth when they are in demand for planting in the field is the determining factor whether this approach will eventually be adopted as a method for supplying planting material of *H. odorata.* Persistent effect of the growth retardant is the key factor to ascertain the recovery rate of the paclobutrazol treated seedlings (Tsan 2000). Those subjected to higher application rates require a longer period to regain normal growth. Subsequent studies on the growth performance of these seedlings when transferred to the field are crucial for the commercial acceptance of this practice.

For this purpose, a study of the growth performance of *H. odorata* seedlings in the field following treatment with paclobutrazol was carried out. These seedlings were treated with various concentrations of paclobutrazol and maintained for one year in the nursery under 40% relative light intensity condition. Their origins were germinated seeds potted in polybags in a medium of soil and sand at a proportion of 2:1. Half a tea spoon (about 5 g) of slow release fertiliser NPK 14:14:14 was applied to each seedling at one- and two-months of age. Then, application of paclobutrazol at rates of 0, 0.5, 1, 2, 4 and 8 g l^{-1} commenced at four months when the seedlings were approximately 10 cm in height. Subsequent applications of the growth inhibitor were carried out at three-month intervals. The spray volume was one litre for 100 seedlings. The treated seedlings were then allowed to undergo

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a recovery period of three months when they were one year old. The same slow release fertiliser (NPK 14:14:14) was applied to the recovering seedlings at the same concentration (5 g) after the first and second month of the recovery period. The seedlings were transferred to the field at Bukit Hari, Kepong after this recovery period of three months. There were 10 replicates (seedlings) for each treatment.

During the first year in the field, a tea spoon (about 10 g) of nitrophoska green (15:15:15) was applied monthly to each seedling. For the subsequent years, a table spoon (about 20 g) of nitrophoska blue special (12:12:17:2) was applied at intervals of three months. Weeding as well as pest and disease control was carried out when necessary. The seedlings were monitored for height and stem diameter (at 10 cm above ground) at intervals of three months over a period of three years. The relative growth rates for these two parameters were calculated from the primary data and subjected to analysis of variance. Means of these relative growth rates that resulted from the varying application rates of paclobutrazol were compared using Tukey's studentised range test.

When planted out in the field after the recovery period of three months in the nursery, the untreated control seedlings were the tallest and had the biggest stem diameter compared with those subjected to the application of paclobutrazol (Tables 1 and 2). Seedlings treated with the growth inhibitor at the rate of 8 g l^{-1} were the shortest. However, stem diameter growth of treated seedlings did not vary significantly to one another.

During the first three months after transplanting to the field, *H. odorata* seedlings treated with the growth regulator at rates ranging from 0.5 to 2 g l^{-1} showed higher relative growth rates for height when compared with the control seedlings (Table 1). The seedlings stored by this growth regulator at a rate of 4 g l^{-1} gained more growth for height and stem diameter than the control seedlings from six to twelve months after out planting. Seedling treated with the growth retardant at rates of 1 and 2 g l^{-1} were the tallest and had the biggest stem diameter at nine and twelve months after transplanting (Figures 1 and 2).

During the second year after transplanting, the control *H. odorata* seedlings generally remained with low relative growth rates for height and stem diameter when compared with the treated seedlings (Tables 1 and 2). Those following treatment with 1 g l^{-1} paclobutrazol were the tallest by the end of the second year (Figure 1). They showed a difference of more than 1 m in height compared with the control seedlings. On the other hand, the seedlings subjected to storage by the application of 2 g l^{-1} paclobutrazol had the biggest stems in terms of diameter at two years after transplanting (Figure 2).

All *H. odorata* seedlings under study, however, showed a decline in the relative growth rates for height and stem diameter throughout the third year after transplanting (Tables 1 and 2). The seedlings following treatment with paclobutrazol at a rate of 1 g l^{-1} remained the tallest by the end of the study period (Figure 1). Those treated with the growth regulator at rates of 1, 2 and 4 g l^{-1} had the biggest stems in diameter among all the transplanted seedlings, ranging from 4.6 to 5.1 cm at 36 months after transplanting (Figure 2).

Hopea odorata seedlings stored with the application of 8 g l^{-1} paclobutrazol were the shortest and had the smallest stems in diameter during the first year after out planting (Figures 1 and 2). They recorded higher relative growth rates for these two parameters only in the second year after transplanting when compared with the control seedlings and those subjected to lower application rates (Tables 1 and 2). However, they remained the shortest with the smallest stem diameters in the third year when the control seedlings showed greater relative growth rates for these two parameters.

Table 1 The relative growth rate of height of the paclobutrazol-treated *Hopea odorata* seedlings after out planting to the field

Rate ($g\ l^{-1}$)	Height when planted out (cm)	Relative growth rate of height after out planting according to months ($cm\ cm^{-1}\ day^{-1}$)											
		0–3	> 3–6	> 6–9	> 9–12	> 12–15	> 15–18	> 18–21	> 21–24	> 24–27	> 27–30	> 30–33	> 33–36
0	44.3[a]	0.0010[b]	0.0014[bc]	0.0009[b]	0.0015	0.0003[b]	0.0017	0.0017	0.0021	0.0019[ab]	0.0008	0.0017	0.0006
0.5	27.4[b]	0.0035[a]	0.0026[abc]	0.0022[ab]	0.0019	0.0021[ab]	0.0019	0.0026	0.0019	0.0021[a]	0.0015	0.0012	0.0002
1	24.8[b]	0.0024[ab]	0.0050[a]	0.0036[ab]	0.0022	0.0030[ab]	0.0030	0.0032	0.0024	0.0011[ab]	0.0011	0.0009	0.0006
2	23.4[bc]	0.0023[ab]	0.0051[a]	0.0030[ab]	0.0041	0.0039[a]	0.0033	0.0021	0.0005	0.0011[ab]	0.0012	0.0006	0.0005
4	21.0[bc]	0.0009[b]	0.0040[ab]	0.0055[a]	0.0040	0.0048[a]	0.0026	0.0021	0.0014	0.0017[ab]	0.0013	0.0009	0.0006
8	15.3[c]	0.0004[b]	0.0004[c]	0.0023[ab]	0.0034	0.0055[a]	0.0040	0.0039	0.0028	0.0006[b]	0.0013	0.0015	0.0006

Means with the same letters within each column are not significantly different at 5% level of significance.

Table 2 The relative growth rate of stem diameter of the paclobutrazol-treated *Hopea odorata* seedlings after out planting to the field

Rate ($g\ l^{-1}$)	Stem diameter when planted out (mm)	Relative growth rate of stem diameter after out planting according to months ($mm\ mm^{-1}\ day^{-1}$)											
		0–3	> 3–6	> 6–9	> 9–12	> 12–15	> 15–18	> 18–21	> 21–24	> 24–27	> 27–30	> 30–33	> 33–36
0	5.80[a]	0.0040[a]	0.0019[bc]	0.0012[b]	0.0004[b]	0.0016[b]	0.0014[b]	0.0022[ab]	0.0011	0.0016[a]	0.0019	0.0013	0.0011[a]
0.5	4.51[b]	0.0037[a]	0.0042[ab]	0.0019[ab]	0.0010[ab]	0.0028[ab]	0.0026[ab]	0.0022[ab]	0.0009	0.0009[ab]	0.0014	0.0012	0.0005[ab]
1	4.22[b]	0.0038[a]	0.0044[ab]	0.0035[ab]	0.0026[ab]	0.0039[a]	0.0026[ab]	0.0020[b]	0.0008	0.0011[ab]	0.0007	0.0010	0.0003[b]
2	4.12[b]	0.0035[a]	0.0064[a]	0.0022[ab]	0.0033[a]	0.0032[ab]	0.0031[ab]	0.0023[ab]	0.0008	0.0006[b]	0.0013	0.0007	0.0002[b]
4	3.96[b]	0.0008[b]	0.0056[a]	0.0045[a]	0.0030[a]	0.0041[a]	0.0028[ab]	0.0022[ab]	0.0013	0.0010[ab]	0.0015	0.0008	0.0007[ab]
8	4.21[b]	0.0004[b]	0.0005[c]	0.0026[ab]	0.0015[ab]	0.0044[a]	0.0046[a]	0.0037[a]	0.0009	0.0010[ab]	0.0011	0.0013	0.0004[ab]

Means with the same letters within each column are not significantly different at 5% level of significance.

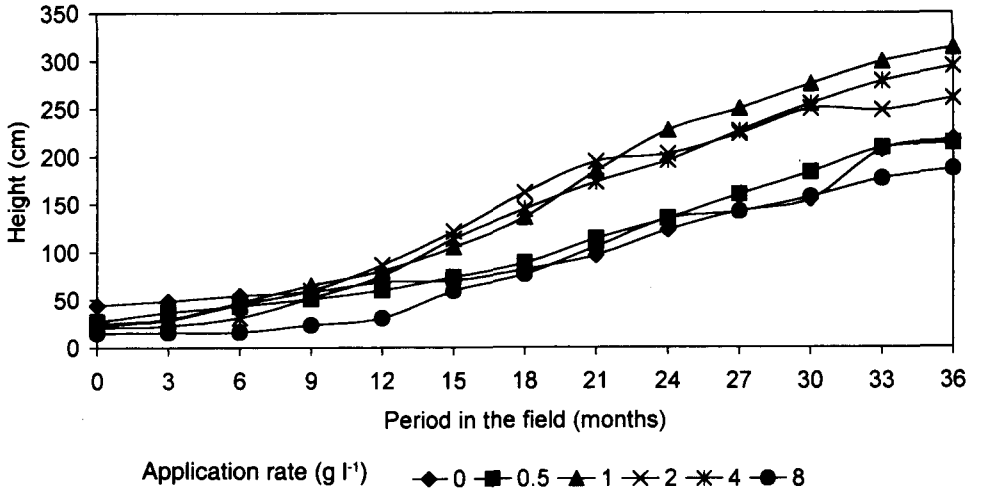

Figure 1 Height of the paclobutrazol-treated *Hopea odorata* seedlings after transplanting to the field

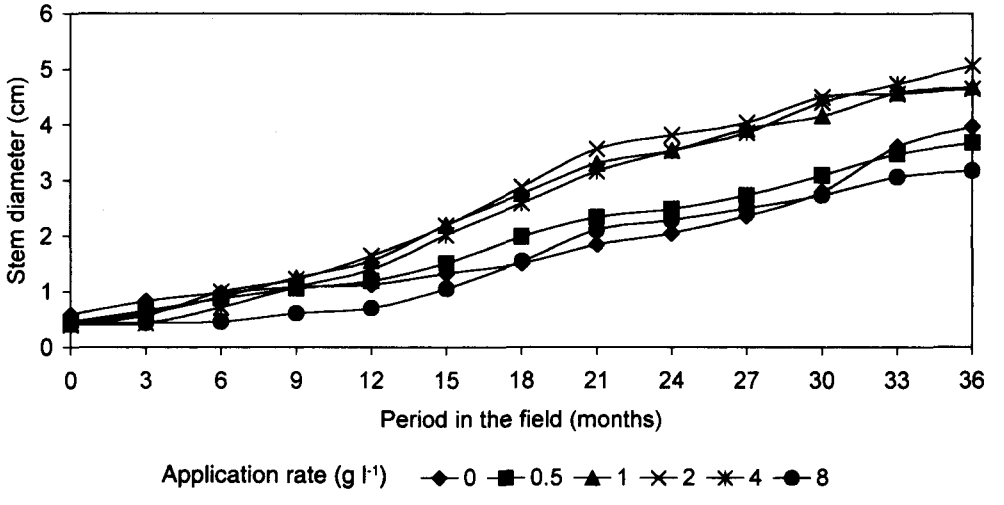

Figure 2 Stem diameter of the paclobutrazol-treated *Hopea odorata* seedlings after transplanting to the field

The results of this study indicated that *H. odorata* seedlings, subjected to the application of paclobutrazol at rates ranging from 1 to 4 g l^{-1} during storage, were the best in terms of growth after out planting to the field. This implied that controlled growth during storage in the nursery was favourable for better growth performance of the seedlings when transferred to the field. A possible reason for this would be the higher availability of conserved energy in the treated seedlings as a result of the controlled growth during storage when compared with that in the untreated control seedlings. In fact, planting materials left

untreated in the nursery for long periods have always been reported to fail to perform well when planted out in the field. The effects of growth inhibition in the seedlings treated with paclobutrazol at a higher rate of 8 g l^{-1}, however, persisted in the field for one year (Figures 1 and 2). These seedlings only gained more growth after the persistent growth inhibition effects were over.

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