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Research article

Vegetative propagation of *Homalium foetidum* (Roxb.) by leafy stem cutting in a non-mist and mist propagation systems

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Abstract

Homalium foetidum Roxb. (Malas) is a commercial timber species in Papua New Guinea harvested from natural forests. It is not systematically planted as plantation species due to lack of its propagation techniques and silviculture practices information. This study on indole-3-butyric acid (IBA) concentrations and rooting media effect on the rooting of leafy stem cuttings of Malas were investigated in two experiments; using the misting system and non-mist propagator. In experiment 1, cuttings set under the misting system treated with 0.3% and 0.8% IBA inserted in coarse sand and course sand-peatmoss mixture (1:1, by volume) respectively, both achieved 100% rooting after 4 weeks. In experiment 2, cuttings set in a non-mist propagator recorded a greater value of 75% and 87.5% rooting of 0.3% and 0.8% IBA respectively, inserted in fine sand, compared to the lower rooting percentage of other treatment combinations. On the basis of these results, 0.3% or 0.8% IBA can be applied for mass propagation of *H. foetidum* cuttings in a misting system and non-mist propagators to promote rapid root formation. Rooting media of (i) coarse sand and (ii) coarse sand-peatmoss mixture (1:1, by volume) are ideal for cuttings under misting system and (iii) fine sand for cuttings set in non-mist propagators for the multiplication of rooted cuttings.

Keywords: Vegetative propagation, Cuttings, Malas, Rooting cuttings, Indole-3-butyric acid

1. Introduction

Homalium foetidum (Roxb.) Benth. (Flacourtiaceae) commonly known in Papua New Guinea (PNG) as Malas is a commercial timber species [2] which is primarily obtained from natural forests [11]. To sustain timber production, efforts have been made to replant the species in logged-over forests. Nevertheless, plantation development of this species is restricted due to difficulties in obtaining seeds from selected parent trees from the natural forest, primarily, due to nature of the seeds which are so minute and can be easily dispatched by wind. Secondly, the morphology of Malas trees of average height of 80.7 m make it difficult to harvest seeds from the tree top (plant specimen records at Lae National Herbarium, PNG). In addition to these hindrances is the lack of studies into its reproductive phenology (flowering and fruiting), seed biology, seed storage and germination. Consequently, planting stock production is not achieved to initiate reforestation programs concerning the species in PNG. The problem in producing regular planting stock can be overcome through vegetative propagation by stem cuttings or tissue culture [1, 3, 4].

Several studies have reported that applying auxins to basal end of cuttings rapidly increases the rate of rooting, increases final rooting percentage and increase the number of roots of cuttings [4, 6]. Given this rooting success of leafy stem cuttings, a number of studies demonstrated that high concentrations of auxins can be inhibitory to rooting; therefore determining an optimum concentration for an understudied species is needed [6].

The type of rooting medium used is also important in rooting initiation and development. Cuttings of many species root successfully in a variety of rooting media [5], nevertheless, both the number of roots and rooting percentage, may be greatly influenced by the kind of rooting medium used [5]. This report describes two separate experiments designed to assess the effects of (i) auxin concentrations, and (ii) rooting media on rooting ability of *H. foetidum* in order to define the optimum treatments for consistent higher rooting percentage in stem cuttings of this species.

2. Materials and methods

Plant materials were harvested from previously pruned 5-year-old trees at the PNG Forest Research Institute (PNG FRI) nursery on the July 6, 2011. These trees were planted through wildings (seedlings) collected in March 2004, in the Nakanai area in West New Britain Province (W.N.B.P.), PNG to propagate for vegetative propagation studies at PNG FRI. A total of 116 seedlings of 30-50 cm in height were up-rooting from the forest floor, leaves reduced to half to prevent desiccation prior to planting into 4 large size (60 x 40 cm) polythene bags filled with forest soil. The severed wildings were airfreight to Lae, PNG FRI on the 4th March 2004. They were transplanted individually into large polythene bags (10 x 9 cm) filled with a mixture of coarse sand and forest soil (1:1, by volume). They were regularly watered and pruned as hedge-potted-plants until they were planted in an open environment in 2007 in the vicinity of PNGFRI nursery.

2.1. Harvesting and preparation of cuttings

Approximately, 30-50 cm branches (from the apex) were collected using secateurs between 8 and 9 am in the morning. They were immediately placed in a bucket half filled with tape water. The leaves were mistered with a spaying container during the collection period and also during the preparation of cuttings in the mist house. All cuttings were cut to 6 cm length and leaf area of 50 cm² prior to treating with IBA solution for 5 seconds and inserting in the rooting media either under misting system or in a non-mist propagator.

Experiment 1: Effect of rooting media and IBA on rooting under misting system

Experimental treatments consisted of three rooting media: fine sand (2 mm or less), coarse sand (2-4 mm, obtained by sieving river sand), and a mixture of coarse sand and peatmoss (1:1 by volume). The second treatment was indole-3-butyric acid (IBA) concentrations: 0.3% IBA, 0.8% IBA, and control (no IBA applied). A split-plot design was used in this experiment. Whereby, rooting media was applied as a main-plot and IBA treatments as sub-plot. Cutting tray (26 x 36 cm) containing 12 cutting pots of 5 x 9 x 6.8 cm filled with each rooting medium was randomised four times along the bench under the misters. Four treated cuttings per IBA concentration and control were then randomly planted per cutting tray. A total of 144 leafy stem cuttings were set under the misting system.

Experiment 2. Effect of rooting media and IBA on rooting in a non-mist propagator

Low-technology non-mist propagator was constructed has described by Leakey *et al*. [5]. The propagator consisted of a wooden frame enclosed in clear polythene. A propagation container (69 L x 5 W x 3 H) was placed in the non-mist propagator. At the base of container, stones of 6-10 cm were laid, followed by gravel (2-3cm) and subsequent rooting medium. The propagation container was filled with water to a depth of 5 cm below the surface of the rooting medium. Whenever the propagator was open, the cuttings were sprayed frequently with water from a knapsack sprayer. The rooting media component in the non-mist was sub-divided into 6 compartments. The rooting media of fine sand and mixture of coarse sand and peatmoss were randomised twice. Four treated cuttings per IBA concentration and control were then randomly planted per compartment (rooting medium). A total of 72 leafy stem cuttings were set in the non-mist propagator.

2.2. Cutting evaluation or assessment of cuttings

After 28 and 38 days of inserting cuttings under misting system and a non-mist propagator respectively, cuttings were carefully removed from the rooting medium and observations were recorded on rooting, number of roots per rooted cutting and their lengths. Assessment was carried out for each trait per cutting.

3. Data analyses

Data collected were collated into a excel spread sheet, prior to processing using a Pivot Table. The rooting traits (rooting percentage, root number per rooted cutting, root length) were subjected to two-way analyses of variance (ANOVA) using the SPSS statistical software, version 17.0 [12].

4. Results

Experiment 1: Effect of rooting media and IBA on rooting under misting system

Percentage rooting of cuttings

Percentage rooting of cuttings with adventitious roots of *H. foetidium* showed no substantial variation among the rooting media and IBA concentration ($p > 0.05$). The highest rooting percentage with a mean value 93% was obtained in cuttings inserted in coarse sand while those set in a mixture of coarse and peatmoss had 79.2% rooting success (Table 1). Cuttings treated with 0.8% IBA recorded a higher mean value of 95.8% for rooting percentage, while cuttings without IBA treatment (control) recorded the least, 77.1% (Table 1).

From ANOVA, interaction between rooting media and IBA concentrations were observed to have significant effect on rooting percentage ($p < 0.05$). The interaction of rooting media and IBA concentrations has recorded a mean value of 100% rooting percentage of cuttings treated with 0.8% IBA inserted in a rooting medium constituting a mixture of coarse sand and peatmoss (Table 2). Similar output of 100% rooting percentage was displayed for cuttings treated with 0.3% IBA inserted in coarse sand. The least values of 62.6% and 75% rooting success were found for cuttings treated with 0.3% IBA and without IBA respectively, planted in the rooting media of coarse sand-peatmoss mixture (Table 2).

Table 1: Effects of rooting media and concentration of hormones on the number of roots, root lengthy and rooting percentage of juvenile stem cuttings under mist system

Treatments	Number of roots	Root length (cm)	Rooting percentage (%)
Rooting media			
Fine sand	7.0a	2.2a	85.4a
coarse sand	7.3a	2.1a	93.7a
Coarse sand + Peatmoss	6.2a	1.7a	79.2a
Concentration of hormones			
Nil	5.2a	1.7a	77.1a

0.3% IBA	6.3a	1.8a	85.4a
0.8% IBA	9.0a	2.4a	95.8a

Note: Any two numbers from the same column followed by the same letter are not significantly different at *p* = 0.05 level (ANOVA test).

Table 2: Interactive effect of rooting media and hormone concentration on the number of roots, root length and rooting percentage (%) of juvenile cuttings under mist system

Rooting medium/hormone concentration	Number of roots	Root length (cm)	Rooting percentage (%)
Fine sand x Control	4.9a	1.6a	68.8a
Fine sand x 0.3% IBA	7.9c	2.6c	93.8a
Fines and x 0.8% IBA	8.3b	2.4c	93.8a
Coarse sand x Control	6.3b	2.2c	87.5b
Coarse sand x 0.3% IBA	6.6b	1.9a	100c
Coarse sand x 0.8% IBA	8.9d	2.2c	93.8a
Coarse sand+Peatmoss x Control	4.5a	1.4a	75b
Coarse sand+Peatmoss x 0.3% IBA	4.3a	1.0a	62.5b
Coarse sand+Peatmoss x 0.8% IBA	9.9d	2.6c	100c

Note: Any two numbers from the same column followed by the same letter are not significantly different at *p* = 0.05 level (ANOVA test).

Number of roots and length

Rooting media and IBA concentrations had no significant effect on the number of roots and length produced ($p > 0.05$). Although, variation in root number per rooted cutting and root length were not determined greater root number (>7) and root length (>2.0 cm) were obtained in cuttings set in fine and coarse sand (Table 1). Greater root number and length per rooted cutting were attained for cuttings treated with 0.8%.

The interaction between rooting media and IBA concentrations did display significant effect on the number of roots per rooted cutting and root length ($p < 0.05$) (Table 2). Cuttings treated with 0.8% IBA inserted in coarse sand-peatmoss mixture showed greater number of roots of 9.9 and root length of 2.6 cm per rooted cuttings among other treatment combinations. Conversely, cuttings treated with 0.3% IBA and set in coarse sand-peatmoss mixture recorded least number of roots of 4.3 and 1.0 cm of root length (Table 2).

Experiment 2: Effect of rooting media and IBA on rooting in a non-mist propagator

Percentage rooting of cuttings

Percentage rooting of cuttings with adventitious roots of *H. foetidium* recorded significant differences among the rooting media and IBA concentration ($p > 0.05$). Great rooting percentage with a mean value 66.7% was obtained in cuttings inserted in fine sand while those set in coarse-peatmoss mixture had the least of 16.7% (Table 3). Cuttings treated with 0.8% IBA recorded a higher mean value of 54.2% for rooting percentage, while cuttings without IBA treatment (control) recorded the least, 16.7% (Table 3).

Interaction between rooting media and IBA concentrations had significant effect on rooting percentage ($p < 0.05$). Cuttings supplied with 0.8% IBA prior to setting in fine sand had displayed 87.5 per cent rooting success followed by those treated with 0.3% inserted in fine sand with a mean value of 75% (Table 4). Cuttings treated with 0.3% IBA and those without IBA inserted in coarse sand-peatmoss mixture and coarse sand respectively, both recorded the least of 12.5 per cent rooting. Unfortunately, cuttings without IBA (control) inserted in a coarse sand-peatmoss mixture all died without developing roots (Table 4).

Number of roots and length

Rooting media and IBA concentrations showed significant effect on the number of roots and length ($p < 0.05$). Greater root number per rooted cutting of 4.5 and mean root length of 4 cm were recorded for cuttings set in fine sand compared to 0.3 and 1.9 cm of root number and length respectively for cuttings set in coarse sand-peatmoss mixture (Table 3). Cuttings without IBA treatment displayed a least number of roots (1.4) and root length (0.8 cm), while greater number of roots and length of 3.5 and 3.6 cm respectively were recorded for cuttings treated with 0.8% IBA (Table 3).

The interaction between rooting media and IBA concentrations showed significant effect on the number of roots per rooted cutting and root length (Table 4). Cuttings treated with 0.8% IBA inserted in fine sand recorded greater number of roots and length compared to other treatment combinations. Very low root numbers and length were found for cuttings supplied with IBA concentrations or without planted in coarse sand-peat moss mixtures (Table 4).

Table 3: Effects of rooting media and concentration of hormones on the number of roots, root lengthy and rooting percentage of juvenile stem cuttings in a non-mist propagator

Treatments	Number of roots	Root length (cm)	Rooting percentage (%)
Rooting media			
Fine sand	4.5a	4a	66.7a
coarse sand	1.6b	1.4b	33.3b
Coarse sand + Peatmoss	0.3c	1.9b	16.7c
Concentration of hormones			
Nil	1.4a	0.8a	16.7a
0.3% IBA	1.5a	2.9b	45.8b
0.8% IBA	3.5b	3.6c	54.2b

Note: Any two numbers from the same column followed by the same letter are not significantly different at p = 0.05 level (ANOVA test).

Table 4: Interactive effect of rooting media and hormone concentration on the number of roots, root length and rooting percentage (%) of juvenile cuttings in a non-mist propagator

Rooting medium/hormone concentration	Number of roots	Root length (cm)	Rooting percentage (%)
Fine sand x Control	3.3a	2.2b	37.5a
Fine sand x 0.3% IBA	3a	5.1a	75d
Fine sand x 0.8% IBA	7.1b	4.7c	87.5e
Coarse sand x Control	1c	0.1e	12.5b
Coarse sand x 0.3% IBA	1.5c	2b	50c
Coarse sand x 0.8% IBA	2.4d	2.1b	37.5a
Coarse sand+Peatmoss x Control	0	0	0
Coarse sand+Peatmoss x 0.3% IBA	0.1e	1.8f	12.5b
Coarse sand+Peatmoss x 0.8% IBA	0.9f	4d	37.5a

Note: Any two numbers from the same column followed by the same letter are not significantly different at p = 0.05 level (ANOVA test).

5. Discussion

The results of these experiments demonstrated the important role of determining an optimal rooting medium in the process of vegetative propagation in these two propagation systems. The ability of cuttings to survive and produce more and required length of roots is very ideal, which depends on adequate moisture retention and adequate drainage in the rooting medium. Coarse sand-peatmoss mixture serves this purpose in the either of the propagation systems in this studied species. However, cuttings inserted in this rooting medium rooted poorly in the non-mist propagator than those in the same rooting medium in the misting propagation system.

The rooting success range of 60-100% of cuttings inserted in coarse sand-peatmoss mixture under the misters is an ideal rooting medium. This finding is supported of Tchoundjei *et al*. [13] who concluded that *Prunus Africana* cuttings rooted better in sawdust and sand-sawdust mixture than sand alone.

In addition, cuttings planted in fine and coarse sand under the misters displayed a range of rooting success of 68-100% (Tables 1, 2). Coarse sand is too porous and unable to retain moisture but cuttings rooted well in it. Cuttings inserted in fine sand in the non-mist propagator showed rooting success above 65% than coarse sand and coarse sand-peatmoss mixture (Table 3, 4). In support of this finding, experiment on the effects of different concentrations of IBA, rooting media and cutting origins on the rooting of leafy stem cuttings of *Cordia alliodora* reported that higher rooting percentages were recorded in gravel and sand than in sawdust [8]. Studies conducted on *Cordia alliodora* and *Vochysia hondurensis* in Costa Rica reported higher rooting percentages in fine sand and fine gravel respectively than other rooting media [5]. Study of *H. foetidum* is in support of many studies on rooting cuttings of many tree species, that leafy stem cutting of tree species response differently to various rooting media [5].

H. foetidum cuttings responded well to 0.8% IBA concentration resulting in >65% rooted success than 0.3% IBA and the control (no IBA applied) in the non-mist propagator. In contrast, distinct differences among IBA concentrations and the control were not found for cuttings set in the misting system. The IBA concentrations and the control did show more than 77% rooting success in this propagation system. The ability of rooting hormone to promote adventitious roots development in stem cuttings is well known, and has been attributed to enhancement of transported carbohydrate to the base of the cuttings [3]. In spite of this, several tree species experimented indicate contrasting responses to IBA application.

For instance, Leakey *et al*. [6] reported that optimum IBA concentration for rooting of *Triplochiton scleroxylon* was 0.4%, while according to Mesen, [9] 1.6% IBA is required for optimum rooting percentage of *Cordia alliodora* and failed to root without IBA addition. The relatively high rooting percentage recorded here in cuttings set in the misting system suggest that regardless of whether Malas cuttings are supplied with IBA concentrations or not, these would still develop adventitious roots. It may also imply that the species is well supplied with endogenous auxins. Studies of other tropical tree species, such as *Shorea macrophylla* [7], *Nauclea diderrichii* [4], *Vochysis hondurensis* [5] and *Milicia excelsa* [10] rooted successfully without IBA application.

The interaction between fine sand x IBA concentrations (0.3% & 0.8%) was found to be an ideal treatment combination for propagating Malas cuttings in the non-mist propagator. In the misting system, the treatment combination of rooting media x IBA concentrations had displayed 60-100% rooting success. These treatment combinations found in these experiments are optimum treatments to use in multiplication of Malas planting stock for reforestation programs in the country.

Conclusion

These results indicate that *H. foetidum* is amenable to vegetative propagation using the techniques described. The rooting percentage of more than 60% achieved in non-mist and misting propagation systems indicate that multiplication of planting stock by vegetative means for large scale planting can be achieved. At present, it is so difficult to obtained *H. foetidum* seeds from the natural forest due to the nature of the seeds. Difficulties in obtaining seeds have restricted further research concerning the species. Thus, vegetative propagation can be achieved using the techniques described here for successful multiplication of stock plants of this species for reforestation projects.

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