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ACIDIFICATION OF FOREST SOIL FOR DIPTEROCARP PLANTING STOCK PRODUCTION

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ทำการทดลองผลิตกล้าไม้ตระกูลยาง 2 ชนิดคือ ไม้ตะเคียนทอง (*Hopea odorata*) และไม้พยอม (*Shorea roxburghii*) ที่ศูนย์เมล็ดพันธุ์ไม้ป่าอาเซียน-แคนาดา ซึ่งดินและน้ำมีสภาพเป็นด่าง มีปริมาณแคลเซียมคาร์บอเนตอยู่สูง ค่า pH ประมาณ 8 ทำการปรับสภาพความเป็นกรดของดินโดยใช้กำมะถันผงและสารส้มที่ 7 ระดับคือ (1) สภาพควบคุม (ไม่มีการผสมสารใด ๆ) (2) ผสมกำมะถันผงในดินปริมาณ 2.22 กก/ม^3 (3) ผสมกำมะถันผงในดินปริมาณ 3.89 กก/ม^3 (4) ผสมกำมะถันผงในดินปริมาณ 5.56 กก/ม^3 (5) ผสมสารส้มบดในดินปริมาณ 2.78 กก/ม^3 (6) ผสมสารส้มบดในดินปริมาณ 5.56 กก/ม^3 (7) ผสมสารส้มบดในดินปริมาณ 8.33 กก/ม^3

ผลการทดลองพบว่า ในการผลิตกล้าไม้ตะเคียนทองอายุ 10 เดือน ในสภาพที่มีดินและน้ำเป็นด่าง ควรใช้สารส้มร่วมกับกำมะถันผงในอัตรา 5.56 กก/ม^3 และ 8.33 กก/ม^3 ตามลำดับ โดยจะมีเปอร์เซ็นต์การรอดตายเฉลี่ยเท่ากับ 91.83 % และการผลิตกล้าไม้ตะเคียนทองที่มีอายุน้อยกว่า 7 เดือน ก็สามารถใช้กำมะถันผงในอัตราที่ลดลงมาได้คือ 3.89 กก/ม^3 ส่วนการผลิตกล้าไม้พยอมอายุ 10 เดือน ควรใส่กำมะถันผงในระดับ 5.56 กก/ม^3 ซึ่งจะมีเปอร์เซ็นต์การรอดตายเฉลี่ยเท่ากับ 49.03 % การเพิ่ม pH ของดินในทุกระดับไม่มีผลต่อการรอดตายของไม้ทั้ง 2 ชนิด สำหรับการผลิตกล้าไม้พยอมซึ่งมีเปอร์เซ็นต์การรอดตายต่ำมาก ควรมีการศึกษาถึงการปรับคุณสมบัติอื่น ๆ ของดินต่อไป

ABSTRACT

Acidification of forest soil for 2 Dipterocarp species (*Hopea odorata* and *Shorea roxburghii*) for planting stock production was conducted at the ASEAN-Canada Forest Tree Seed Centre, where both soil and water contain high calcium carbonate. The pH of both soil and water is around 8. Acidification treatments had 7 levels : (1) control, (2) addition of sulfur powder at 2.22 kg/m^3, (3) addition of sulfur powder at 3.89 kg/m^3, (4) addition of sulfur powder at 5.56 kg/m^3, (5) addition of aluminum sulfate at 2.78 kg/m^3, (6) addition of aluminum sulfate at 5.56 kg/m^3 and (7) addition of aluminum sulfate at 8.33 kg/m^3. The results showed that for 10 months *H. odorata* planting stock production, addition aluminum sulfate and sulfur at rate 5.56 kg/m^3 and 8.33 kg/m^3 respectively, was recommended. However, applying sulfur powder at 3.89 kg/m^3 was enough for producing 7-month seedlings. The average survival percentage was 91.83. Addition of sulfur powder at the rate of 5.56 kg/m^3 was recommend for *S. roxburghii* planting stock production. The survival percentage was 49.03. Acidification at every level had no effect on seedling survival of both species. Improving soil characteristics to improve survival rate of *S. roxburghii* in alkaline conditions should continue to be studied.

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INTRODUCTION

pH affects the availability of essential nutrients, which is greatest at pH 6.2 to 6.8 for soil-based media and at pH 5.4 to 6.0 for soiless media (Nelson, 1985). Munns (1986) and Mahandrappa (1974) found that soil pH or acidifying factors directly or indirectly influence every part of the system of micro-organism symbiosis.

Nelson (1985) found that it is possible to grow successful crops at much higher and lower pH levels, but the further one strays from the recommended range, the greater are the odds against success.

In alkaline planting media, it is necessary to lower pH of the media to avoid plant nutrient deficiency. This can be accomplished by adding sulfur, aluminum sulfate, or iron sulfate with a crop absent or present. All of these sources react in the soil to ultimately form sulfuric acid. (Nelson, 1985)

Tayama 1966) reported that the quality of sulfur or aluminum sulfate necessary to lower the pH level of greenhouse root media from 8.0 to 5.0 was 2.1 kg/m^3 and 5.2 kg/m^3 respectively.

The ASEAN-Canada Forest Tree Seed Centre is located in Muak-lek district, Saraburi province where the geology component is mountainous limestone. Soil has a high lime content, which generally gives high pH. Calcium carbonate loving-species such as *Tectona grandis* can grow well, while some species such as *Acacia mangium*, *Dalbergia cochinchinensis* and some Dipterocarp species seem impossible to grow. Problems are not only high soil pH but also high water pH as well, which is nearly 8 in both cases.

Experiments were conducted to solve these problems by selecting potting media and types of Mycorrhizal tablet, and encouragement of the poor growth of 1-year old *H. odorata* by soil mycorrhizal inoculation and fertilization. There were non-significant differences in growth which was still very poor. (Kajornsrichon, 1992)

The primary planting medium and water used in seedling production were local top soil and running water. Therefore, these problems urgently need to be solved prior to studies on other aspects of seedling production. Water acidification needs equipment and more intensive technique more than soil acidification. This experiment was on soil acidification only.

MATERIAL AND METHODS

This experiment was carried out at the nursery of the ASEAN-Canada Forest Tree Seed Centre, from June 1992 - March 1993 with 2 Dipterocarp species : *Hopea odorata* and *Shorea roxburghii*. The layout was a RBD with 3 replications, each of which contained the following treatments;

1. Control : no acidification
2. Addition of sulfur powder at 2.22 kg/m^3
3. Addition of sulfur powder at 3.89 kg/m^3
4. Addition of sulfur powder at 5.56 kg/m^3
5. Addition of Aluminum sulfate at 2.78 kg/m^3
6. Addition of Aluminum sulfate at 5.56 kg/m^3
7. Addition of Aluminum sulfate at 8.33 kg/m^3

An experimental unit consisted of 24 seedlings grown in Hiko box containers (133 ml/cavity). Seedlings were grown under 2-layers of black net shade (8% relative light intensity)

After the pH of soil was determined, sulfur powder and aluminum sulfate were applied. Seedlings were transplanted in late April. From one month after transplanting, diameter and height of seedlings were measured periodically. The survival rate of seedlings at 8 months was recorded. Analysis of variance was used according to the following model :

$$X_{ijk} = \mu + T_i + B_j + e_{ijk}$$

where

X_{ijk} = height or diameter for the k^{th} seedling in the j^{th} block for the i^{th} treatment.

μ = overall experimental mean

T_i = effect of i^{th} treatment

B_j = effect of j^{th} block

e_{ijk} = random error term

F-test was used for comparing among treatments.

The multiple Range Test-Scheffe Method -at 95 % confidence level was used for comparing the means.

RESULTS AND DISCUSSION

Hopea odorata

Average heights and diameters of seedlings at different levels of acidification are shown in Tables 1 and 2, and illustrated in Figures 1 and 2.

In the first 4 weeks, the growth of seedlings grown in soil acidified by aluminum sulfate was better than the growth in soil acidified by sulfur powder. However, after 14 weeks seedling grew better in soil acidified by sulfur powder (Figure 1 and 2). Aluminum sulfate is water soluble, while sulfur is not, therefore the aluminum sulfate reacts very rapidly, whereas sulfur must be oxidized by soil microbes, which requires several weeks to be completed (Nelson, 1985). Seedlings grow well in soil acidified by sulfur powder at the rate of 2.22 kg/m^3 and 3.89 kg/m^3 in the third month, and 3.89 kg/m^3 in the sixth month, and at 5.56 kg/m^3 after the seventh month.

For *H. odorata* seedlings production in alkaline conditions, aluminum sulfate at 5.56 kg/m^3 with sulfur powder should be applied. The rate of sulfur application depends on the final age of the seedlings. For seedlings aged 6-7 months, 3.89 kg/m^3 seems to be the optimum for both growth and cost, while for seedlings aged 10 months, applying sulfur at the rate of 5.56 kg/m^3 was better.

The averaged percentage of seedling survival was 91.83. Analysis of variance showed non-significant differences. This means that every level of acidification had no effect on seedling survival.

Shorea roxburghii

Average heights and diameters of seedlings at different levels of acidification are shown in Tables 3 and 4, and illustrated in Figures 3 and 4.

In the first two months the height growth of seedlings was good in the control or no acidification, after that height growth of seedlings grown in soil acidified by sulfur powder at the rate of 5.56 kg/m^{3}were the best.

Diameter growth was best in soil acidified by aluminum sulfate at the rate of 5.56 kg/m^3 in the first month, and in soil acidified by sulfur powder at rate of 5.56 kg/m^3 in the second month. After that the diameter growth was good in the control.

The seedling survival rate was 49.03 %. The analysis of variance showed non-significant differences. This means that the level of acidification had no effect on seedling survival.

The control showed moderate diameter and height growth, while acidified treatments, using aluminum sulfate were the lowest. The height growth of seedlings grown in soil acidified by sulfur at 5.56 kg/m^3 was the best and quite different from other treatments. To produce 10-month *Shorea roxburghii* seedlings in these alkaline condition, 5.56 kg/m^3 of sulfur should be applied.

CONCLUSION

The results showed that for 10-month-old *H. odorata* planting stock production, addition of aluminum sulfate and sulfur at the rate of 5.56 kg/m^3 and 8.33 kg/m^3 respectively, is recommended. However, for producing 7-month-old *H. odorata* seedlings,

Table 1. Average heights (cm) of *Hopea odorata* seedlings in different levels of acidification

Seedling age (weeks)	Control	Soil acidification					
		Sulfur powder (kg/m^3)			Aluminum sulfate (kg/m^3)		
		2.22	3.89	5.56	2.78	5.56	8.33
4	8.39ab	8.31ab	8.54a	7.90b	8.60a	8.47a	8.17ab
6	8.39ab	8.39ab	8.86a	8.26b	8.51ab	8.51ab	8.54ab
8	8.65	9.11	9.04	8.54	8.80	8.96	8.71
10	9.29	9.49	9.78	9.15	9.40	9.15	9.19
14	9.81bc	10.61a	10.75a	10.29ab	10.11abc	9.67bc	9.57c
23	11.04c	13.54b	15.26a	14.65ab	11.10c	11.53c	10.90c
27	10.96c	14.54b	15.90ab	15.97a	11.25c	10.46c	10.75c
31	11.98b	16.24a	17.28a	17.57a	11.89b	12.66b	11.59b
35	12.21c	16.99b	18.34ab	18.86a	12.83c	13.12c	12.66c
39	12.58c	17.53b	18.24ab	19.36a	13.08c	13.77c	12.79c

Note : Means within a column followed by different letters are significantly different at the 0.05 according to the Scheffe test.

Table 2. Average diameters (mm) of *Hopea odorata* seedlings in different levels of acidification

Seedling age (weeks)	Control	Soil acidification					
		Sulfur powder (kg/m^3)			Aluminum sulfate (kg/m^3)		
		2.22	3.89	5.56	2.78	5.56	8.33
4	1.45c	1.45c	1.46c	1.44c	1.59b	1.69a	1.69a
6	1.71ab	1.72ab	1.75a	1.68ab	1.69ab	1.59c	1.65bc
8	1.74ab	1.78a	1.77a	1.75ab	1.73ab	1.66b	1.68ab
10	1.82b	1.84b	1.85ab	1.79b	1.93a	1.81b	1.81b
14	2.10ab	2.09ab	2.03ab	2.12a	2.03ab	1.99b	2.02ab
23	2.42c	2.70a	2.72a	2.66a	2.46b	2.46b	2.42b
27	2.52c	2.81a	2.77ab	2.79a	2.52c	2.48c	2.56bc
31	2.59b	2.89a	2.93a	3.02a	2.58b	2.59b	2.65b
35	2.52b	2.97a	3.02a	3.07a	2.50b	2.47b	2.48b
39	2.58b	3.03a	3.05a	3.21a	2.57b	2.62b	2.58b

Note : Means within a colum followed by different letters are significantly different at the 0.05 according to the Scheffe test.

applying sulfur powder at 3.89 kg/m^3 was enough. The average survival percentage was 91.83. Addition of sulfur powder at 5.56 kg/m^3 is recommended for *S. roxburghii* planting stock production. The survival percentage was 49.03. Acidification at every level had no effect on seedling survival of both species. Improving soil characteristics to improve survival rate of *S. roxburghii* in alkaline conditions needs further study.

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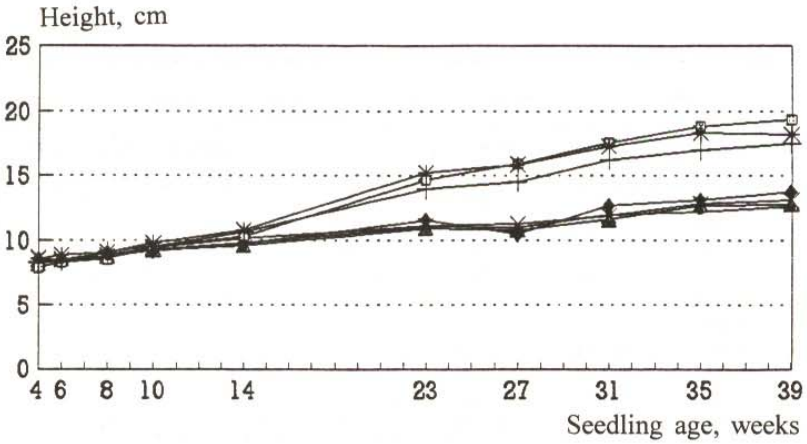
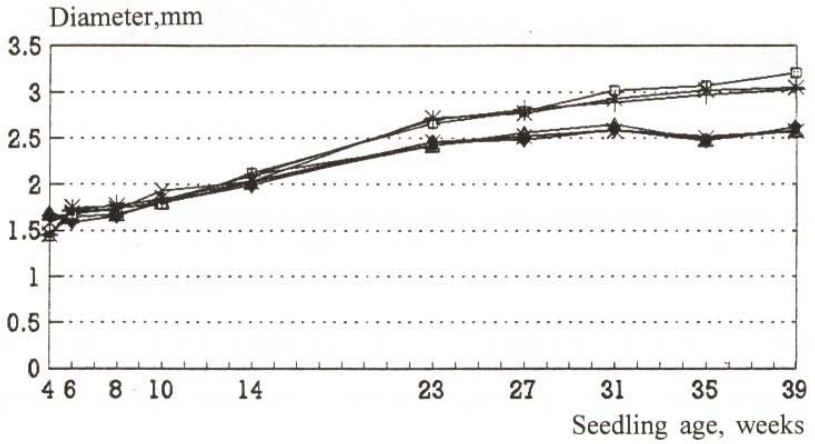


Note: ,control ; ,addition of sulfur powder at 2.22 kg/m^3 ; ,addition of sulfur powder at 3.89 kg/m^3 ; ,addition of sulfur powder at 5.56 kg/m^3 ; ,addition of aluminum sulfate at 2.78 kg/m^3 ; ,addition of aluminum sulfate at 5.56 kg/m^3 ; ,addition of aluminum sulfate at 8.33 kg/m^3

Figure 1. Average heights of *Hopea odorata* seedlings in different levels of acidification.



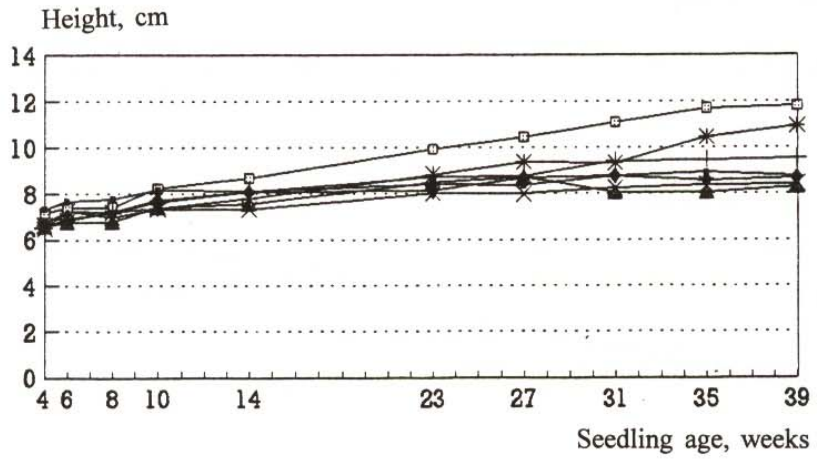
Note: ,control ; ,addition of sulfur powder at 2.22 kg/m^3 ; ,addition of sulfur powder at 3.89 kg/m^3 ; ,addition of sulfur powder at 5.56 kg/m^3 ; ,addition of aluminum sulfate at 2.78 kg/m^3 ; ,addition of aluminum sulfate at 5.56 kg/m^3 ; ,addition of aluminum sulfate at 8.33 kg/m^3

Figure 2. Average diameters of *Hopea odorata* seedlings in different levels of acidification.

Table 3. Average heights (cm) of *Shorea roxburghii* seedlings in different levels of acidification

Seedling age (weeks)	Control	Soil acidification					
		Sulfur powder (kg/m^3)			Aluminum sulfate (kg/m^3)		
		2.22	3.89	5.56	2.78	5.56	8.33
4	7.35ac	6.53bc	8.54a	7.17abc	6.51c	6.74abc	6.58bc
6	7.70a	6.94bc	8.86a	7.44ab	7.29abc	7.28abc	6.77c
8	7.78a	7.18ab	9.04	7.44ab	6.98b	7.22ab	6.79b
10	8.19a	7.64ab	9.78	8.24a	7.34b	7.75ab	7.42b
14	8.15ab	8.11ab	10.75a	8.68a	7.36b	8.09ab	7.59b
23	8.40b	8.75b	15.26a	9.92a	8.03b	8.12b	8.49b
27	8.36c	8.78bc	15.90ab	10.43a	8.00c	8.70bc	8.75bc
31	8.76b	9.71b	17.28a	11.07a	8.24b	8.76b	8.06b
35	8.92cd	9.45c	18.34ab	11.69a	8.36dc	8.59cd	8.05d
39	8.79bc	9.51b	18.24ab	11.78a	8.43bc	8.68bc	8.31c

Note : Means within a column followed by different letters are significantly different at the 0.05 according to the Scheffe test.



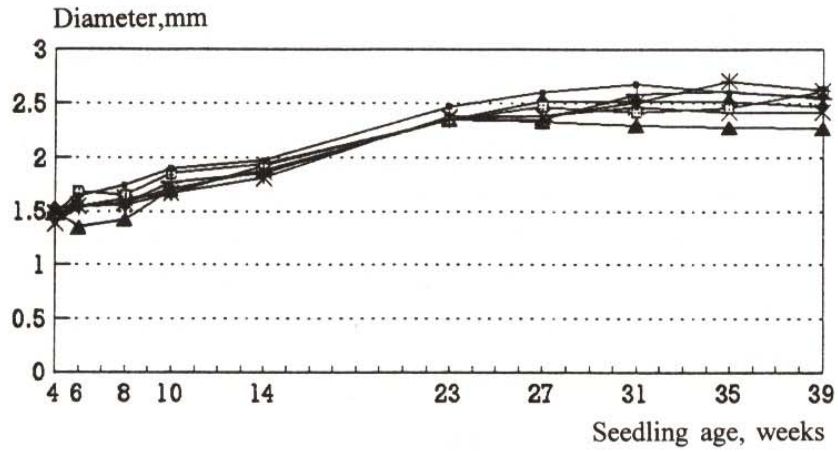
Note: -●-,control ; -+-,addition of sulfur powder at 2.22 kg/m^3 ; -✳-,addition of sulfur powder at 3.89 kg/m^3 ; -⊞-,addition of sulfur powder at 5.56 kg/m^3 ; -✕-,addition of aluminum sulfate at 2.78 kg/m^3 ; -◆-,addition of aluminum sulfate at 5.56 kg/m^3 ; -▲-,addition of aluminum sulfate at 8.33 kg/m^3

Figure 3. Average heights of *Shorea roxburghii* seedlings in different levels of acidification.

Table 4. Average diameters (mm) of *Shorea roxburghii* seedlings in different levels of acidification

Seedling age (weeks)	Control	Soil acidification					
		Sulfur powder (kg/m^3)			Aluminum sulfate (kg/m^3)		
		2.22	3.89	5.56	2.78	5.56	8.33
4	1.41ab	1.42ab	1.48ab	1.46abc	1.38b	1.52a	1.50ab
6	1.64abcd	1.55bcd	1.54d	1.68ac	1.546cd	1.55bcd	1.35e
8	1.74a	1.57b	1.58b	1.65ab	1.62ab	1.56bc	1.42c
10	1.90a	1.77abcd	1.71bd	1.85abd	1.67d	1.67cd	1.70bcd
14	1.97	1.85	1.87	1.94	1.81	1.92	1.88
23	2.47	2.36	2.36	2.35	2.38	2.35	2.35
27	2.60a	2.35b	2.38ab	2.47ab	2.38ab	2.52ab	2.33b
31	2.68	2.59	2.51	2.46	2.47	2.52	2.30b
35	2.60ab	2.61ab	2.71a	2.46ab	2.42ab	2.52ab	2.28d
39	2.56ab	2.54ab	2.62a	2.61a	2.42ab	2.47ab	2.27b

Note : Means within a column followed by different letters are significantly different at the 0.05 according to the Scheffe test.



Note: ,control ; ,addition of sulfur powder at 2.22 kg/m^3 ; ,addition of sulfur powder at 3.89 kg/m^3 ; ,addition of sulfur powder at 5.56 kg/m^3 ; ,addition of aluminum sulfate at 2.78 kg/m^3 ; ,addition of aluminum sulfate at 5.56 kg/m^3 ; ,addition of aluminum sulfate at 8.33 kg/m^3

Figure 4. Average diameters of *Shorea roxburghii* seedlings in different levels of acidification.