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Coppice Growth of Some Tropical Tree Species in Mindanao Island, the Philippines

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Abstract

A study on coppicing capability of some tropical trees, including *Leucaena leucocephala, Gmelina arborea, Tectona grandis and Pileostigma malabaricum var. acidum*, was undertaken with particular emphasis placed on their initial sprout growth and the factors affecting the production of sprouts in Mindanao Island, the Philippines. The growth of sprouts of these species was so outstanding: it was 5-10 m in height and 4-6 cm in diameter in the first year. This could lead to shorten the rotation period to a greater degree compared with temperate trees, provided that the site for coppicing is adequately selected. A stump size was recognized to have a positive effect on the initial growth of sprouts. This suggests that larger trees may be cut to produce more and larges sprouts. A reciprocal relation existed between the sprout growth and the sprout density regarding the stump of G. arborea and T, grandis. On the basis of this relationship, a threshold density of sprouts was estimated in order to identify appropriate criteria in conducting a spout thinning on a given stump. Concerning the cutting system, a clean-cutting or a heavy crown thinning would be suitable for producing larger and healthier sprouts to reproduce the stands.

Discipline: Forestry and forest products
Additional key words: density effect, fast growing, thinning, tropical silviculture

Introduction

In many broad-leaved trees and some coniferous trees, new sprouts are produced from the stumps in response to impediments such as cuttings, mechanical injuries or fires. This method for reproducing forests is one type of asexual reproduction: it is called coppice. The coppice method is the simplest and perhaps the oldest way among all the methods used for regenerating forests. In temperate regions, the coppice system had been widely developed for the production of fuelwood until the petroleum gas and oil was introduced. Extensive information on the silvicultural property of coppice have been made available as far as the temperature forest species are concerned[2–4]. However, there are limited data available, in terms of both quantitative and silvicultural aspects, on the coppice of tropical trees, although some tropical trees[14] are recognized to have high coppicing abilities.

This paper presents an example of the coppice growth of selected tropical tree species in Mindanao Island, the Philippines with particular reference to their initial growth and the factors affecting the production of sprouts. The objective of the present

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Table 1. Growth of sprouts of *L. leucocephala* in thinned stands

Location	Plot[a)]	Thinning ratio (%)	Mean stump diameter (cm)	Mean number of sprout (no./stump)	Mean maximum height of sprout (m)	Mean maximum diameter of sprout (cm)	Mean diameter of sprout (cm)	Mean basal area of sprout (cm^2)
Naawan	Crown thinning	19	8.7±0.9[b)]	5.8±0.7	3.9±0.7	1.5±0.3	0.9±0.1	4.5±1.4
Naawan	Low thinning	18	6.7±0.9	2.1±0.4	3.4±2.5	1.5±0.7	1.2±0.5	2.9±2.2
Upper Iligan	Crown thinning	25	10.2±2.6	2.3±1.5	2.8±1.5	1.2±0.9	1.0±0.6	2.0±0.9
Upper Iligan	Low thinning	22	3.7±0.5	2.6±0.5	2.4±0.5	0.7±0.2	0.6±0.1	0.5±0.01

a): Crown thinning; thinning for dominant trees, Low thinning; thinning for suppressed trees.
b): Mean value ±95% confidence limit.

study is to provide data necessary for the development of an adequate coppice management system of the selected species. The trees studied are: *Leucaena leucocephala, Gmelina arborea, Tectona grandis* and *Pileostigma malabaricum* var. *acidum*. *L. leucocephala* is a leguminous tree. It is well known for its fast growth and multiple use in the tropics. *G. arborea* is planted widely throughout Southeast Asia for its rapid growth. *T. grandis* which has a long history of planting for its excellent quality of timber is one of the most important plantation species in Southeast Asia. *P. malabaricum* var. *acidum* is a bushy tree growing usually in burned areas.

Study area and method

Field experiments were conducted at four plantations located in the northern part of Mindanao Island. Climatic conditions of the study areas are characterized by tropical monsoon with a dry spell during the period January to April. The average annual rainfall and temperature at Cagayan de Oro from 1950 to 1975 are 1658 mm and 26.8°C, respectively[8)]. Two plantations under the study were in the precinct of Philippines Sinter Corporation (PSC). One of those plantations consisted of *L. leucocephala, G. arborea, P. malabaricum* var. *acidum* and *T. grandis*, each of which was planted in a small lot, respectively, in July 1976. All the standing trees were cut down in February 1982. Another plantation consisted of *L. leucocephala* only planted in July 1976 and cut in January 1983. The other two field experiments were undertaken in the plantations of *L. leucocephala* at Naawan and Upper Iligan, which are both located in the west of Cagayan de Oro. These two plantations are in the concession of Mabuhay Agro-Forestry Corporation. They were established in 1980 at Naawan and in 1978 at Upper Iligan. Two thinning plots were set up in each plantation in 1982: one was thinned for dominant trees (crown thinning), while the other was done for suppressed trees (low thinning) at almost the same thinning ratio on a basal area basis (Table 1).

The growth of sprouts was measured in March 1983. The measurements were taken on diameter at breast height of all sprouts, maximum height of sprout per stump and diameter of all stumps with calipers and scale. Number of dead sprouts was also recorded in addition to the surviving ones on each stump. Height and diameter at breast height and stem volume were measured for *L. leucocephala* stands grown in two sites: one was under favorable conditions and the other under unfavorable conditions, each in Naawan as well as in Talakag situated in the south of Cagayan de Oro.

Results and discussion

After cutting, new sprouts grew rapidly in abundance on most stumps of every species studied. All the sprouts were not likely to grow into full-size trees due mainly to competition among the sprouts. Some of the large and healthy sprouts could remain

Table 2. Growth of sprouts of some tropical trees at clear-cutting areas in the Philippines[a)]

Species	Age of sprout (month)	Mean stump diameter (cm)	Mean number of sprout (no./stump)	Mean maximum height of sprout (m)	Mean maximum diameter of sprout (cm)	Mean diameter of sprout (cm)	Mean basal area of sprout (cm^2)
L. leucocephala	12	20.5±2.9[b)]	3.6±0.5	10.1±1.9	5.3±0.7	3.9±0.6	55.6±14.7
L. leucocephala	2	19.1±3.6	21.0±6.3	2.9±0.2	1.4±0.2	0.9±0.1	9.1± 3.1
G. arborea	12	25.2±6.2	2.9±0.6	7.3±0.8	5.8±1.5	4.4±0.9	61.3±32.7
T. grandis	12	14.2±3.9	3.5±1.0	6.7±1.2	5.2±0.9	3.6±0.6	41.9±16.5
P. malabaricum var. *acidum*	12	18.1±5.3	7.2±3.2	4.9±0.4	4.1±0.9	2.6±0.4	58.1±38.0

a): The data were taken at Philippine Sinter Corporation in Mindanao Island, the Philippines.
b): Mean value ±95% confidence limit.

survived for harvesting. Therefore, the largest sprout on a given stump might be a practical indicator of coppicing ability for a given stump. On this basis, maximum growth as well as mean growth was investigated.

1) Growth of sprouts

Growth of sprouts and number of surviving sprouts in each species are shown in Table 2. Mean maximum-height of sprouts of *L. leucocephala* was 10 m one year after cutting, which was the largest among those materials studied. It reached 3 m in the first two-month period, demonstrating an extremely rapid initial growth. On the other hand, *P. malabaricum* var. *acidum* showed the smallest maximum-height, i.e. 5 m. Mean maximum-diameter did not vary significantly among the species studied. However, the mean diameters of *L. leucocephala, G. arborea* and *T. grandis* were significantly larger than that of *P. malabaricum* var. *acidum*. Regarding the mean number of surviving sprouts per stump, *P. malabaricum* var. *acidum* was the largest among the species studied. Number of sprouts per stump possibly depends on the growth stage, decreasing in the growing period. This is illustrated by the significant difference of sprout number per stump in *L. leucocephala* between the two stages: i.e. two months and one year after cutting (Table 2). Growth of *P. malabaricum* var. *acidum* was the smallest. This might be closely associated with its greater number of sprouts than the other species, resulting in a bushy tree type of that species. The basal area of sprouts per stump expressed by total sum of the diameters and number of sprouts on a given stump did not show significant variations among the species. These results indicate that growth of sprouts denoted by diameter and basal area do not vary significantly among the species, while growth in height and number of surviving sprouts have variations. The plant height was the largest in *L. leucocephala* and the smallest in *P. malabaricum* var. *acidum,* whereas the greatest number of sprouts was seen in the latter species.

The tropical trees under study were much faster in their initial growth of sprouts, compared with the temperate trees. In the coppice stands examined, mean maximum-height was 5–10 m, mean maximum-diameter at breast height was 4–6 cm, and mean basal area of sprouts was 42–61 cm^2/stump in a year after cutting (Table 2). This is much greater than the growth of sprouts in *Quercus acutissima,* which has the greatest coppicing ability in Japan; that is 1.5 m of maximum-height, 1.7 cm of maximum-diameter and 10.9 cm^2 of basal area per stump on an average in a year after cutting, even under a favorable condition[11)]. *Aluns rubra,* which shows a high ability of sprouting in North America, produced the sprouts with 2.6 m of maximum-height and 2.4 cm of maximum-diameter in two years after cutting[10)]. The sprouts of *Platanus occidentalis* and Sweet Chestnut reached a height of some 1.5–2.3 m in the first year[3)]. These examples reveal that the tropical trees have much greater abilities of initial sprouting compared with the temperate trees.

A comparison of the growth between the sprouts and the planted trees of *L. leucocephala* showed that the initial growth of the former was much faster than the latter (Tables 2 and 3). At the age of one year

Table 3. Growth of the stands of *L. leucocephala*[a)]

Location	Plot	Age of stand (year)	Tree density (no./ha)	Mean height (m)	Mean diameter (cm)	Basal area (m^2/ha)	Stem volume (m^3/ha)
Naawan	Favor. site	2.7	2,500	11.3	7.4	11.0	70.2
Naawan	Unfavor. site	2.7	2,500	6.5	5.1	5.3	17.6
Talakag	Favor. site	2.6	2,500	8.7	6.2	9.7	49.9
Talakag	Unfavor. site	2.6	2,500	3.3	2.0	1.5	4.0

a): The data were taken at the concession of Mabuhay Agro-Forestry Corporation.

after cutting, maximum growth was 10.1 m in height, and 5.3 cm in diameter on an average in the coppice stands of *L. leucocephala*. However, in three years after planting even under favorable conditions at two sites, *L. leucocephala* reached 11.3 m and 8.7 m in average height, and 7.4 cm and 6.2 cm in average diameter at breast height, respectively. This suggests that the initial growth of sprouts be much superior to that of the planted trees. The growth rate of stands increases with increased tree age, reaching the maximum, and thereafter it decreases gradually. Such a growth pattern varies among the tree species and locations. *Albizia falcataria* was estimated to reach its maximum growth at the age of three years[9)]. In this connection, it is reported that the growth of the fast growing tree species in the tropics generally culminates at the age between eight and ten years[5)]. It is inferred therefore that the growth rate of the coppice stands reaches the maximum at the earlier stage compared with that of the plantation. As far as *L. leucocephala* coppice stands at PSC are concerned, the age of culmination may presumably be one to two years after cutting.

2) Factors affecting growth of sprouts

Sprouting abilities are affected by various characters of stumps as well as by environmental conditions. In the present study, stump size, sprouts density and thinning of stands were analyzed to examine their effects on the production of sprouts. *L. leucocephala* was not included in the analysis, because some stumps of this species showed distorted effects caused by sprout thinning after cutting.

(1) Stump size

It was recognized that stump size gave some effects on the production of sprouts in each species, although there were variations. The number of surviving sprouts per stump was significantly related to the diameter of the stump. Sprout height and diameter per stump tended to increase as the diameter of the stump became bigger. The growth of sprouts was significantly correlated with the stump diameters. The basal areas of sprouts per stump had positive correlations with diameters of the stump. The basal areas of sprouts increased exponentially with increased diameters of stumps in *G. arborea* and *P. malabaricum* var. *acidum* (Fig. 1). These results suggest that larger stumps produce more and larger sprouts, as far as the maximum diameter of the stump is approximately 40 cm. There might be however a certain upper limit of stump size in reaching maximum sprout growth: beyond that level, sprout growth rate would become smaller[1,12)].

(2) Density of sprouts

Sprout density, expressed by the number of sprouts per unit basal area of stumps, showed a reciprocal relation[13)] with the growth of sprouts in *G. arborea* and *T. grandis* (Fig. 2). The number of sprouts here include dead sprouts to indicate their initial number. The relationships in each species are presented as follows:

$$1/D = 0.166 + 3.11\rho \quad (R = 0.894^{**}: \text{ for } T.\ grandis) \ldots\ldots (1)$$

$$1/D = 0.157 + 7.80\rho \quad (R = 0.700^{**}: \text{ for } G.\ arborea) \ldots\ldots (2)$$

where D is the mean sprout diameter at breast height and ρ is the number of sprouts per unit basal area of stumps.

These equations imply that the density effect works reciprocally on the sprout growth; in other words, decreased diameter of sprouts results from the increased sprout density on a given stump. However, the density effects in sprouts were not strong enough as seen in the planted trees. It is reported that the same relationship as above exists in *E. camaldulensis* in Thailand[7)]. Variations in such a reciprocal relationship might be caused by two factors: one is that the population of sprouts is subjected to a greater edge effect, and the other is that the growth of sprouts is more interrelated each other, compared with that of planted trees.

The threshold number of sprouts which would give a significant density effect on the growth of sprouts is estimated on the basis of equations (1) and (2) above. The intersection point of the two asymptotes on the reciprocal curve is designated as a point B[13]. The point B on the x coordinate is assumed to be the threshold of sprout density to bring about a strong density effect on the growth of sprouts on a given stump. Based on the point B, the threshold number of sprouts which caused a strong density effect on the sprout growth on the stump with various sizes could be estimated (Fig. 3). Thinning of sprouts would lead to an increased growth of the remaining sprouts[3]. Therefore, the lines in Fig. 3 provide adequate criteria for sprout densities to start thinning for various stump sizes in facilitating the growth of sprouts. Fig. 3 indicates that the threshold number of sprouts is generally larger in *G. arborea* than in *T. grandis*. This may be caused by the difference in sprout growth between those two species (Table 2).

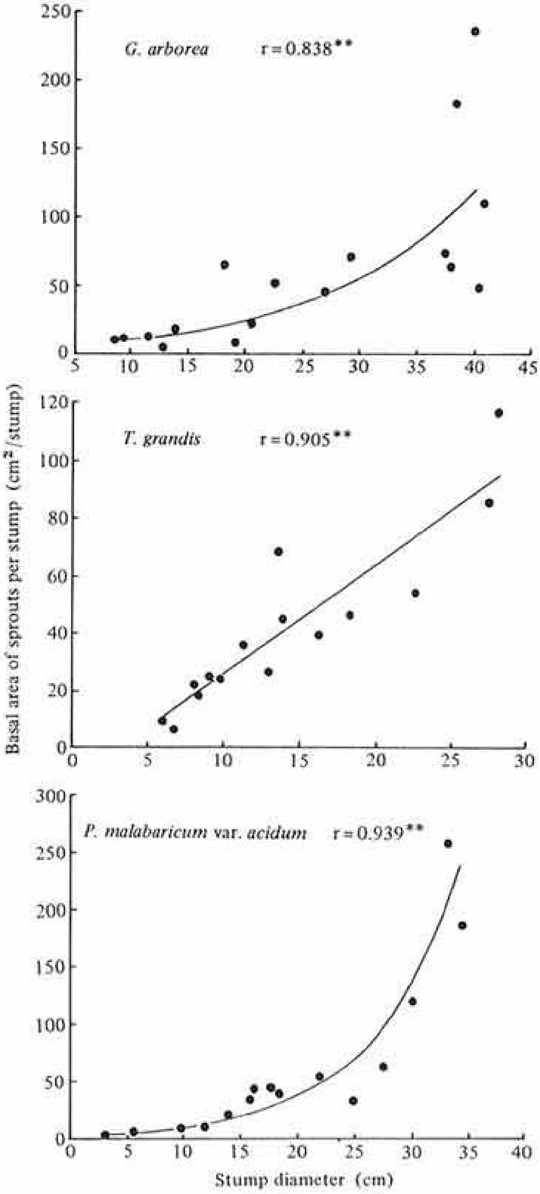

Fig. 1. Relationship between basal area of sprouts and stump diameter

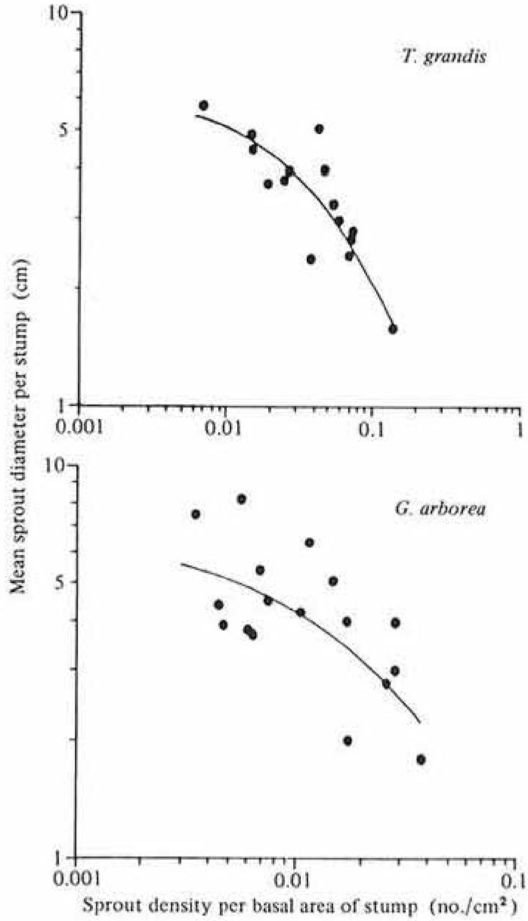

Fig. 2. Relationship between mean sprout diameter and sprout density

The same reciprocal relationship was observed between the sprout height and sprout density, indicating that the former was affected by the latter. Such a relationship is hardly seen in tree stands.

(3) Thinning of stands

The sprouts of *L. leucocephala* could grow to certain degrees under shaded conditions. Canopy of the thinned stands was nearly closed in a year after thinning. Even under such conditions, the sprouts grew on the thinned stumps. Maximum height and diameter of sprouts of the thinned stands were reduced to the levels of 24–39% and 13–28% of those in clear-cutting areas at PSC, respectively (Tables 1 and 2). Those sprouts had slender stems with small leaves, while a heavy thinning is reported to produce healthier sprouts[6]. Therefore, the heavy thinning or the clear-cutting might be suited to produce larger and healthier sprouts.

Thinning methods affect the production of sprouts. Plant height and basal area of sprouts per stump were larger in crown thinning than in low thinning under the same thinning ratio (Table 1). The same result is reported in *E. camaldulensis* stands[6]. These results are attributed to the fact that the sprout growth is affected by stump size.

Conclusions

As far as those tropical tree species under study are concerned, the coppice system would be the most suitable method for reproducing and harvesting the trees in the earlier time in the areas where their stands have already been established.

The coppicing system generally has the shortest rotation in temperate forests. For example, the rotation periods for the production of firewood are 8–20 years for *Quercus acutissima* and 15–30 years for *Quercus serrata* coppice forests in Japan[4]. Rotation of oak coppice forests requires a period of 15–20 years in producing tan-bark in Europe[14]. The requirements for various broad leaved tree species producing firewood, turnery and fencing are 10–25 years in England[3]. On the contrary, an extremely rapid initial growth of sprouts of some selected tree species could shorten to a greater extent the rotation period of coppicing in the tropics than in temperate areas. However, the rotation period is dependent upon the site conditions. The present study indicated that growth of *L. leucocephala* plantations was affected seriously by site conditions: the plant height in unfavorable sites was reduced to 38–58% of that in favorable sites. The difference in stem volumes was even greater (Table 3). Such a high sensitivity of growth to environmental conditions would be one of the characteristics of the fast growing tree species. Therefore, prerequisite is the site selection in employing a short rotation system of coppice.

Concerning the cutting system, a clear-cutting or a heavy thinning is suited to reproduction of stands of the fast growing species. The stumps of *L. leucocephala* stands in the clear-cutting areas produced more vigorous and healthier sprouts than those in the thinning plots. This shows superiority of clear-cutting to thinning, although frequent clear-cuttings with a short rotation period may cause a decrease in sprout production. One alternative is a heavy crown-thinning.

In practicing coppice, larger trees or stands should be cut to produce more and larger sprouts, although there may be an upper limit of tree size. Sprout thinning would be justifiable for making some products other than mass production such as feulwood and pulpwood. The threshold number of sprouts to initiate the sprout thinning on a given stump with various sizes of *G. arborea* and *T. grandis* provides criteria for conducting the sprout thinning (Fig. 3).

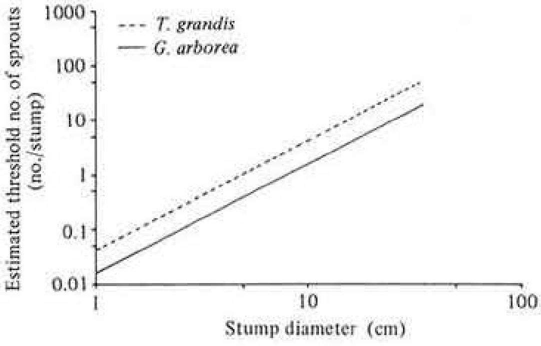

Fig. 3. Relationship between threshold number of sprouts and stump diameter

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