Growth Performance of 6-year-old Teak Plantation under Different Soil Improvement Methods in Khon Kaen Province, Thailand

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Abstract

In general, the soils in Northeast Thailand are moderately to very strongly acidic with low organic content and low fertility. Improvements in soil quality are needed to promote better teak growth in the northeast of Thailand. This study aimed to investigate the growth performance of a 6-year-old teak plantation under various soil improvement methods at the Northeastern Forest Seed Center, Ban Had District, Khon Kaen Province, Thailand. Five different soil improvement treatments were applied as follows: control (no treatment); 2) dolomite application (400 kg/rai; 6.25 rai equals 1 ha); 3) dolomite (400 kg/rai) and organic fertilizer (1 kg/tree); 4) dolomite (400 kg/rai) and chemical fertilizer (15:15:15, 200 g/tree); and 5) mixed fertilizer (dolomite + organic fertilizer + chemical fertilizer at (15:15:15, 200 g/tree). The trees were planted 2 m × 4 m apart. The height and diameter at breast height (DBH) of the trees were recorded. The results showed that there were statistically significant differences in height but not in DBH among the different treatment groups at 6 years after planting. The plots with both dolomite and chemical fertilizer had the greatest height and DBH with averages of 12.3 m and 11.94 cm, respectively.

Keywords: Teak, Soil improvement, Tree growth, Soil properties

Introduction

Teak (*Tectona grandis* Linn.f.) is an important economic tree species in Thailand. Its wood is used for general-purpose timber and its properties make it suitable for a wide range of uses. Teak was, for many decades, the most important exported timber species in Thailand until logging was banned in 1989. There is still high demand from both local and international markets for teak timber. However, owing to the ban and the decrease in natural stands, there is not sufficient teak to meet demand. Thus, there is a great need for improving the growth of teak in plantations in Thailand.

Teak's natural distribution range in Thailand covers mainly areas of the northern and eastern part of the country. Although teak can grow over a wide range of edaphic conditions, the quality and distribution of natural teak is related to the nature of the underlying rock, which is reflected in the soil characteristics. The physical and chemical properties of soil such as texture, depth, porosity, drainage, pH and calcium content determine the growth quality of teak. Teak requires deep, moist, fertile and well-drained sandy loam soils (Kadambi 1951; Kaikini 1956). Teak usually occurs on soils within a pH range of 6.5 to 7.5, rarely grows in soils below 6.0, and suffers poor growth in soils with pH higher than 8.5. However, some studies have shown that teak grows well even in acidic soils (Puri 1951; Pande and Sharma 1986; Banerjee et al. 1986). Teak particularly dislikes laterite soils and is invariably stunted when found on such sites. On limestone, teak flourishes where the rock has disintegrated to form a deep loam layer. Teak requires good subsoil drainage and dislikes stiff clayey soils because its root system is very sensitive to oxygen deficiency (Beumea and Beckman 1956; Kotwal 1959; Yadav and Sharma 1967). Several soil characteristics, including soil moisture, cation exchange capacity, base saturation, phosphorus and calcium content, have been found to affect teak growth (Jungsuksuntigool and Wichiennopparat 1994).

Owing to continuous high demand and short supply from natural stands, teak plantations are an important source for providing a constant supply of teak. However, regions that have both favorable sites and good soil conditions for teak growth are limited. JIRCAS and the Royal Forest Department have established a collaborative project "Development of Techniques for Nurturing Beneficial Indigenous Tree Species and Integrated Management of Agriculture and Forestry in Northeast Thailand, Tropical Monsoon Regions" to carry out studies to develop appropriate techniques for promoting economic tree species in the country.

Under the same collaborative project, a study was carried out to produce a map showing soil suitability for teak growth in several provinces in the northeast of Thailand. The results revealed that approximately half of the total area in several provinces (including Chaiyaphum, Khon Kaen, Buri Ram and Ubon Ratchathani) were identified as being potentially suitable for growing teak. (RFD-JIRCAS Joint Research Project 2015a; RFD-JIRCAS Joint Research Project 2015b).

This study is a part of two subprojects aimed at identifying appropriate soil improvement techniques to promote better teak growth in the northeast of Thailand, where soils are generally acidic and sandy and have low amounts of nutrients required for teak growth, particularly phosphorus and calcium (Keerati–Kasikorn 1984). The know-how regarding soil improvement techniques gained from this study will be further extended to the farmers in these regions.

To improve soil conditions for teak growth in the northeast of Thailand, dolomite, $CaMg(CO_3)_2$, was applied to adjust soil pH and increase calcium content. Organic fertilizer was applied to improve soil physical characteristics and moisture content. Chemical fertilizer was applied to provide additional, major nutrients for teak.

Materials and Methods

The study site was located at the Northeastern Forest Tree Seed Center, Ban Nonesomboon, Nonesomboon Sub-District, Ban Had District, Khon Kaen Province, northeastern Thailand (Fig. 1).

Fig. 1. Location of the study site

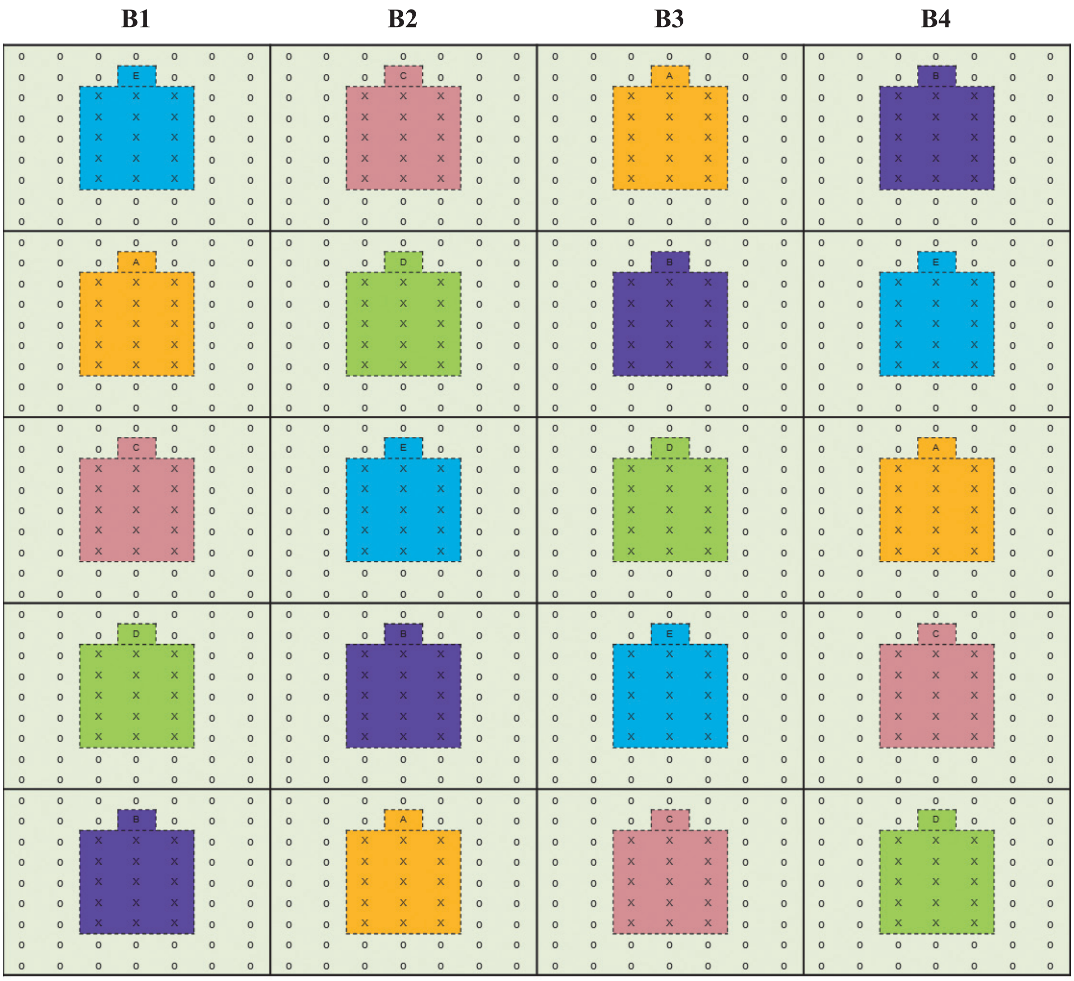
Table 1. Soil characteristics in the study area (Wichiennopparat et al. 2012)

Horizon	Depth (cm)	Organic matter (%)	pH	Avail. P (ppm)
A	0 - 21/35	0.72 - 0.94	4.9 - 5.5	2-5
B1	21/35 - 55/100	0.07 - 0.12	4.9 - 5.8	nil - 3
B2	55/100 - 120+	0.04 - 0.28	4.9 - 5.1	nil - 3

Horizon	Exchangeable Cations (ppm)				Texture
	K	Ca	Mg	Na	
A	51 -59	212 - 364	47 - 50	5 - 9	Sandy
B1	8 - 20	50 - 98	10 - 40	2 - 7	Sandy
B2	12 - 94	34 - 600	15 - 307	7 - 9	Sandy/ Sandy clay loam

Three soil pits were dug at the study area prior to site preparation to investigate the underlying soil conditions. The results regarding some of the chemical and physical properties of the soil in the study area were published in a previous work and are reproduced here in in Table 1 (Wichiennopparat et al. 2012). The experimental area was ploughed using a farm tractor. Teak seedlings were prepared using a tissue culture technique. Clone number 38 was used, which is adapted for the habitat of Ban Dong Sa-ngat, Mae Saleang District, Mae Hong Son Province.

The experimental design was a randomized complete block design with three replicates of 12 trees each. Five soil improvement treatments were tested: A) control (no treatment); B) dolomite (400 kg/rai); C) dolomite (400 kg/rai) and organic fertilizer (1 kg/tree); D) dolomite (400 kg/rai) and chemical fertilizer (15:15:15, 200 g/tree); and E) mixed fertilizer (dolomite + organic fertilizer + chemical fertilizer (15:15:15, 200 g/tree). The treatments were randomly assigned to each subplot. A buffer of non-treated trees surrounded each 18 m × 28 m subplot (Fig. 2). Dolomite was applied to the assigned plots and mixed prior to staking. Organic fertilizer and mixed fertilizer were applied with the planting soil and placed at the bottom of the planting pit (about 30 cm × 30 cm × 30 cm). The seedlings were planted 2 m × 4 m apart in August 2009. Chemical fertilizer was applied evenly around the assigned seedlings 1 month after



Remark: A = Control
B = Dolomite (400 kg/rai)
C = Dolomite (400 kg/rai) + Organic fertilizer (1 kg/tree)
D = Dolomite (400 kg/rai) + Chemical fertilizer (15:15:15, 200 g/tree)
E = Mixed Fertilizer (Dolomite+Organic fertilizer +Chemical fertilizer (200 g/tree)

Fig. 2. Lay out of experimental plots

planting. Total height and DBH of all trees were recorded at 2, 3, 4, 5 and 6 years after planting.

Results

The growth performance of teak in the study area at 2, 3, 4, 5 and 6 years is shown in Table 2. Clearly, the growth of teak in the plots with dolomite and chemical fertilizer, those with dolomite and organic fertilizer and those with mixed fertilizer performed better than in the plots with dolomite alone or controls. A statistically significant difference was found in height but not in DBH of teak at 6 years after planting (P<0.05). The plots with dolomite and chemical fertilizer demonstrated the greatest average height and DBH at 12.3 m and 11.94 cm, respectively. The height and DBH of teak clone no. 38 under the different treatments over time are shown in Figures 3 and 4.

Table 2. Height and diameter at breast height (DBH) of teak clone no. 38 under different soil treatments over time. Different letters indicate significant differences among the five treatments as calculated by Fisher's PLSD test (*P*<0.05).

Treatment	Height (m)					DBH (cm)				
	2 Years	3 Years	4 Years	5 Years	6 Years	2 Years	3 Years	4 Years	5 Years	6 Years
A	4.1	4.8	7.2	8.3[b]	9.6[bc]	3.78	5.55	6.72	8.42	9.71
B	3.9	4.3	7.2	8.3[b]	9.4[c]	3.54	5.21	6.74	8.52	9.84
C	4.7	6.0	8.3	9.7[ab]	11.1[ab]	4.63	6.64	7.70	9.58	10.91
D	4.8	6.2	9.0	11.0[a]	12.3[a]	4.85	7.06	8.54	10.71	11.94
E	5.0	5.9	8.3	9.7[b]	10.5[bc]	4.91	7.19	8.09	9.76	10.75

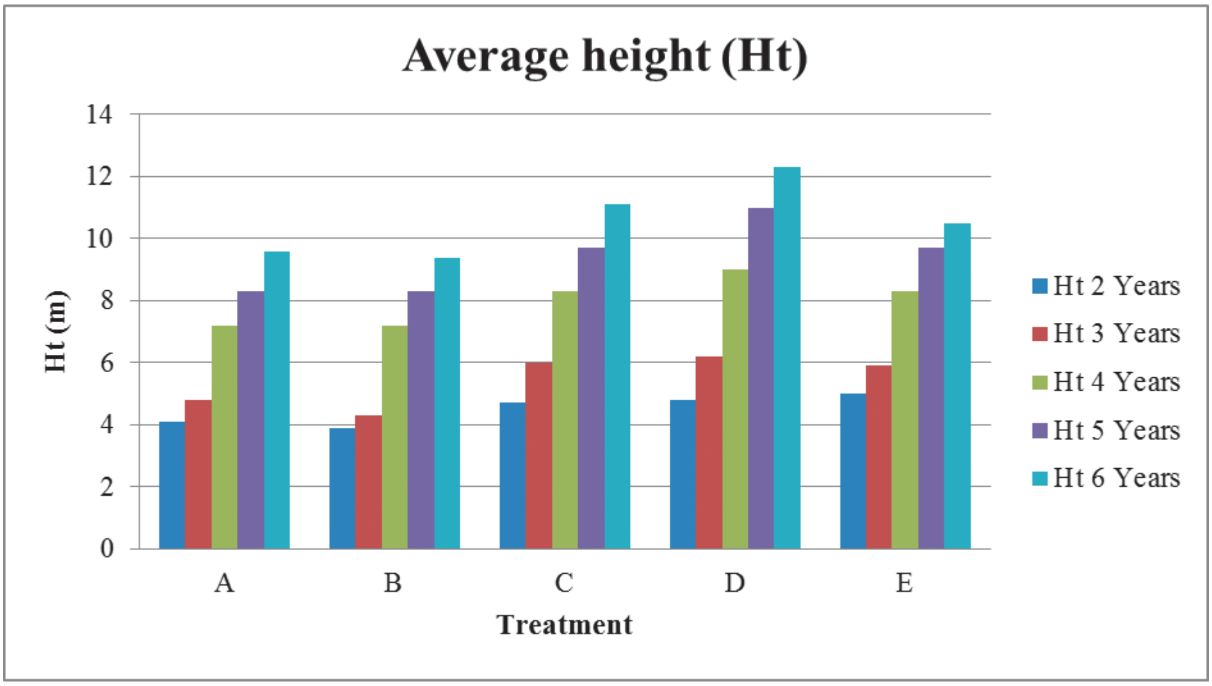


Fig. 3. Height of teak clone no. 38 under different soil treatments over time

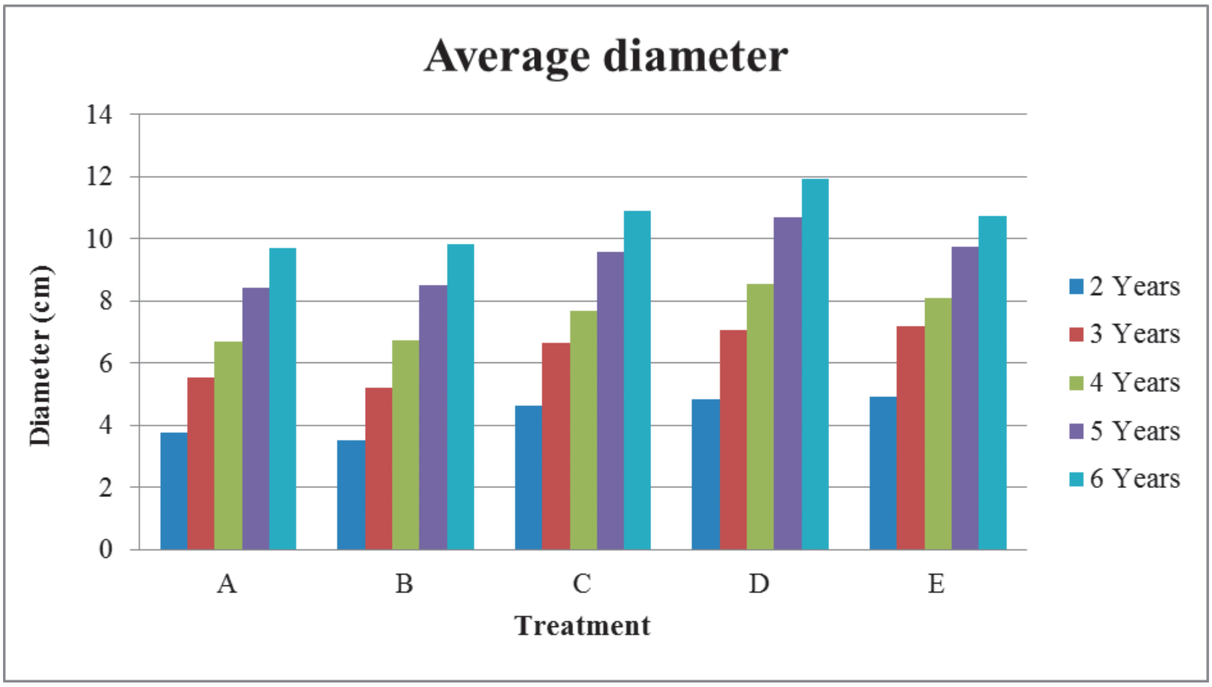


Fig. 4. Diameter at base height of teak clone no. 38 under different soil treatments over time

Discussion and Conclusion

Based on this study, we suggest that application of dolomite is essential for adjusting soil pH and for increasing calcium content in soils for successful teak production in the study area. However, adding dolomite alone, as in treatment B, was not sufficient to improve teak growth. Treatment D, which also included chemical fertilizer, showed the best overall growth. Furthermore, application of organic fertilizer was demonstrated to be helpful for improving growth conditions for teak. The results of this study indicated that various soil treatments could be used to improve teak growth in Northeast Thailand, where soils are acidic, sandy and have low fertility.

In the future, we need to conduct further experiments on teak plantation of different clones. We should also conduct additional experiments in plots with different soil types and in different locations to obtain more information. The spacing for the current study was 2 m × 4 m. There is a possibility that high planting density may inhibit or slow teak growth. To increase growth, it is necessary to thin plantations.

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