Preliminary Results of a Second Clonal Test of Teak (*Tectona grandis* L.f.) in Northeastern Thailand

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Abstract

The objectives of the study were to determine the differences in tree performance among teak clones, to confirm the previous test (first study), and to produce improved genetic materials for teak farmers in Northeastern Thailand. The experiment was undertaken with a randomized complete block design (RCBD) with four replications. Each replication contained three ramets of each clone planted in a row (3 line plot). Twenty-five clones were selected based on the results of the previous field trail (first study), full-sib progeny, teak improvement program, and newly added trees from Navamin teak forest in Mae Hong Son province. In total, 300 seedlings (25 clones × 3 trees/plot × 4 replications) were planted in Khon Kaen province, Thailand.

The preliminary results of height (H), diameter at ground level (DGL), and stem form were evaluated when the seedlings reached 1 year old. In terms of clone performance, statistical analysis showed that there was a significant difference in current annual increment (CAI) of H and DGL of seedlings among clones. The average CAI of H and DGL of each clone were 1.11 m and 1.47 cm ranging from 0.56 to 1.45 m and 0.76 to 1.76 cm, respectively (n = 244). Based on Duncan's multiple range test, clones no. 219, 8c20, MH7 3bb/38, 119, 302, and 300 showed high performance in CAI of H. Among the 25 clones, clone no.3bb/38 showed especially good performance in growth (DGL = 1.69 cm and H = 1.25 m) and stem form. Regarding stem characteristics, we found variations of stem form within and among clones. The forms were classified as four types: straight stem, V shape, branchy, and multi-stem.

Keywords: *Tectona grandis* L.f, Clonal test, Clone, Northeastern Thailand, Khon Kaen

Introduction

Considered as the major clonal test project in Thailand, rooted cuttings were planted in 2000 at three sites (KamphaengPhet, Kanchanaburi, and Songkhla) in order to select teak plus trees and suitable clones to be planted in various sites. Meunpong et al. (2016) evaluated the differences in tree performance among the clones when the trees were 16 years old. It was reported that the site significantly affected tree growth. They found clones significantly affected in DBH in KamphangPhet and Songkhla. The clone performance was ranked based on the growth in diameter. The top clones from KamphaengPhet were 120, 245, 282, 116, 327, 83, 129, 290, 146, and 158. The top clones were totally different from those in Kanchanaburi, which are 336, 335, 265, 324, 273, 160, 271, 267, 89, and 333. At Songkhla, the top clones were 246, 36, 119, 336, 292, 345, 91, 159, 27, and 130. Only clone no. 336 was repeatedly found to be the superior clone at both Kanchnaburi and Songkhla (Meunpong et al. 2016). In brief, the results indicated that the site properties must be taken into consideration in the selection of suitable clones for plantations.

During 2008–2012, we studied the first set of clonal tests of teak in Northeastern Thailand in Udon Thani and Khon Kaen Provinces (Tangmitcharoen et al. 2012: referred to as "the first study" in this report). Unfortunately, the test was not successful because the growth rate of the trees was generally low and there was high variation among individuals. We found no significant difference in the height

and diameter of trees among clones at two sites and no interaction effect between the site and clone in terms of height and diameter. The major reasons for clone failure were environment factors (drought and flooding), improper soil conditions for teak (pH, structure, property, porosity, drainage, and moisture holding capacity) including disturbance by *Eucalyptus* rooting systems nearby, and variations in soil in planting site micro-site effects.

For soil suitability, our study relied on the Land Department Development (LDD; 1990) in which the soil suitability was classified into three classes as 1: well suited, 2: moderately suited, and 3: unsuited. We also used the rank of classes and limitation of soil in the same way as Sukchun and Sakai (2009) (a: slightly acid, d: drainage problem or too wet, f: flood problem, gravel mixed in soil or shallow soil, n: nutrient status, s: soil texture is not suited because of being very sandy soil or having low natural fertility). Based on LDD (1990) and Sukchun and Sakai (2009), our planting site for the first test was categorized as 3s, (moderately suited soil with limitation that the soil texture was not suitable because of being very sandy soil or having low natural fertility). In short, for the first study, we concluded that the low rate of growth was primarily related to the unsuitable conditions both non-preferred soil for teak and severe flooding and drought.

Referred to as the second study, this study was set up again to serve the same objectives as the first study, which were to determine the difference in tree performances among clones and to produce improved genetic material of teak for planting in areas of Northeastern Thailand. This study attempted to overcome the reasons of the failure in the first study by: 1) Planting the seedling at a 2n site (well suited soil but slightly low soil pH for teak) instead of the 3s site (moderately suited soil with a limitation that the soil texture was not suited because of being very sandy soil or having low natural fertility). The 2n site was considered as a relatively good site for teak based on Sukchun and Sakai (2012). They classified 2n conditions as "2–3" for teak growth class, whereas the 3s was classified as "3–4". 2) Planting far away from Eucalyptus plantations. 3) Planting in the early rainy season.

Materials and methods

Experimental plots were planted on 17 July 2014 at Tambon Noonsomboom, Banhaad district, Khon Kaen province near to the Northeast Forest Seed Center. The planting site was classified as 2n.

The 25 tested clones, including unselected clones used as control treatments, were selected based on superior performance and from plus tree selection. The higher performing clones were from the first study (7), full-sib progeny (4); and from a new selection with high-elevation provenance in Mae Hong Son province (3).

Experimental design was a randomized complete block design (RCBD) with four replications. Each replication contained 3 ramets of each clone planted in a row (Fig. 1).

For statistical analysis, means and standard deviation were calculated for diameter at ground level and height. Analysis of variance (ANOVA) was used to determine variation in growth among clones. The Duncan new multiple range test at $P<0.05$ was used to compare the

245	219	28C28	302	37	MH7	271	245	3/27	38
5/79	Control	8C20	11C26	119	302	5C18	Control	119	331
271	V335	14/105	MH17	39	300	MH9	14/105	219	39
300	331	MH9	3/27	5C18	8C20	28C28	MH17	V335	22C50
2AA/15	22C50	38	3BB/38	MH7	37	11C26	3BB/38	5/79	2AA/15
271	Control	2AA/15	22C50	MH9	MH17	5C18	302	22C50	331
V335	8C20	5/79	245	39	V335	119	37	MH7	8C20
119	MH7	37	5C18	3/27	control	11C26	14/105	271	3BB/38
MH17	38	14/105	300	331	5/79	39	MH9	300	3/27
3BB/38	11C26	219	302	28C28	2AA/15	245	28C28	38	219

Remark:

Rep. 4	Rep. 3
Rep. 2	Rep. 1

Fig. 1. Planting design (latinized low-column design) of teak clonal test of 25 clones (4 replications × 3 tree plots)

means for a significant differences among the variables.

We monitored the growth in terms of survival rate, height (H), and diameter at ground level (DGL). The preliminary results were monitored when the trees reached 1 year old. Survival rate and current annual increment (CAI) of H and DGL were measured and analyzed statistically in August 2016.

Results

The major findings of this second study were as follow:

1. The average survival rate of the seedlings was 81.33% ranging from 50% to 100% in each clone.
2. The average CAI of H and DGL of each clone were 1.11 m (SD=0.26) and 1.47 cm (SD=0.26), ranging from 0.56 to 1.45 m and 0.76 to 1.76 cm respectively (n=244).
3. Statistical analysis showed that there was a significant difference in CAI of H and CAI of DGL of seedlings among clones ($p<0.01$) (Table 2).
4. The group of clones that showed high performance in H included clone no. 219, 8c20, MH7 3bb/38, 119, 302, 300, as determined using Duncan's multiple range test.
5. Stem characteristics were classified as four types: straight stem, V shape, branchy, and multi-stem. There were some variations in stem characteristic within and among clones (Fig. 2).
6. Among 25 clones, clone no.3bb/38 showed good performance in growth (DGL = 1.69 cm and H = 1.25 m) and stem form (8 out of 11 with straight stems) (Fig. 3).

Discussion

Teak performs better on deep, well-drained alluvial soils derived from limestone, schist, gneiss, shale and some volcanic rocks. The optimum pH range for better growth and quality was between pH 6.5 and pH 7.5. In contrast, this species performs very poorly, in terms of growth and stem form, on dry sandy soil, shallow soil (hard pan soil or lower water table soil), acidic soil (pH < 6.0) derived from laterite or peatbog, and on compacted or waterlogged soil (Kaosa-ard 1981; Tewari 1992). The growth rate in terms of H and DGL of the seedlings reported in the present study was better than in the first study (Tangmitcharoen *et*

Fig. 2. Examples of stem characteristics categorized as straight stem, v shape, branch, and multi-stem (from left to right).

H (m)	DGL (cm)	CAI of H (m)	CAI of DGL (cm)	No. of ramets	% survival
1.67 (0.73)	3.99 (0.79)	1.25	1.69	11	91.67

Fig. 3. Clone no. 3bb/38 showed outstanding performance in terms of growth and stem form. Numbers in brackets represented the standard deviation.

Table 1. Average of diameter at ground level (DGL), height (H), and current annual increment (CAI) of 1-year-old teak seedlings.

		DGL		H		CAI			
No.	Clone no.	mean (mm)	SD (mm)	mean (cm)	SD (cm)	Height (cm)	DGL (mm)	n	% survival
1	119	40.08	10.18	193.67	48.24	131.08	14.58	12	100.00
2	271	31.17	8.63	96.50	45.09	55.56	13.21	8	66.67
3	300	39.33	12.19	197.91	65.89	122.50	12.63	11	91.67
4	11C26	36.20	42.45	128.50	53.47	73.92	13.73	6	50.00
5	14/105	33.71	19.71	117.42	68.81	69.75	13.06	12	100.00
6	219	37.93	11.49	200.13	75.90	145.00	12.78	8	66.67
7	22C50	36.62	11.89	135.00	64.27	82.17	11.71	6	50.00
8	245	28.51	8.66	100.67	54.62	63.72	8.64	9	75.00
9	28C28	38.39	8.88	174.00	60.86	116.55	17.45	11	91.67
10	2AA/15	36.40	14.31	132.00	69.49	91.13	12.67	12	100.00
11	3/27	33.42	13.50	121.20	63.54	72.40	13.95	10	83.33
12	302	45.74	14.99	188.58	60.13	120.33	16.38	12	100.00
13	331	40.78	13.60	152.80	64.95	99.60	15.97	10	83.33
14	37	28.92	7.79	105.89	51.43	63.94	7.70	9	75.00
15	38	38.20	15.03	141.67	55.80	79.33	11.82	9	75.00
16	39	33.63	8.62	130.90	51.85	91.15	11.25	10	83.33
17	3BB/38	39.88	7.86	167.14	73.13	125.68	16.93	11	91.67
18	5/79	38.52	13.49	165.63	77.17	99.38	9.21	8	66.67
19	5C18	31.58	8.34	114.78	44.34	64.28	7.62	9	75.00
20	8C20	39.33	10.61	193.89	71.29	124.83	13.30	9	75.00
21	MH17	44.73	12.42	200.20	78.23	136.55	15.68	10	83.33
22	MH7	37.00	9.92	146.80	66.96	91.05	13.20	10	83.33
23	MH9	38.42	13.89	133.00	58.77	79.63	16.21	8	66.67
24	V335	37.41	7.70	165.83	52.77	114.96	11.85	12	100.00
25	Control	40.12	7.31	149.08	57.85	90.58	14.43	12	100.00
	Average	37.04	12.54	150.13	61.39	96.20	13.04		81.33
	SD	4.25	6.94	33.00	9.86	26.12	2.72		15.08

Table 2. Statistics for current annual increment (CAI) of height (H) and diameter at ground level (DGL) of 1year-old seedlings.

CAI	Source	DF	Type I SS	Mean square	F value	Pr>F
H	Block	3	19875.005	6625.002	4.48	0.0047
	Clone	24	150412.998	6267.208	4.24	0.0001
DGL	Block	3	430.539	143.513	3.19	0.0251
	Clone	24	2243.623	93.484	2.08	0.0039

al., 2012). This was probably due to better environmental factors (no severe climate conditions after planting and also planting in more suitable soil conditions for teak [2n instead of 3s]).

It was interesting to find one outstanding clone (no. 3bb/38) that performed the best in terms of growth and stem form. This clone originated from the full-sib progeny where both paternal and maternal clones were selected from the plus trees. Further monitoring of this specific clone should be performed.

As for stem characteristics, it seemed that there were variations that could categorized into four types (straight stem, V shape, branchy, and multi-stem). The different characteristics of the stems were not the result of clonal effects, and instead were probably caused by nursery effects or damage during transportation before planting. To obtain more homogeneous measurements, implementation of cutting all seedlings at ground level was probably necessary at an early stage (1–2 years old).

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