

MATERIALS AND METHODS

Materials

1. Teak clones
2. Diameter tape
3. Measuring rod
4. Clinometer
5. Veneer caliper
6. Leaf area device
7. Weight balance
8. Plastic and paper bags
9. Polishing machine
10. Water proof marking pens
11. Computer hardware
12. Scanner
13. Oven
14. Label paper
15. Chain Saw
16. Digging tools

Methods

Sites Selection

The present study was conducted in four locations, including Teak Improvement Center in Lampang, TPC Seed Center in Uthai Thani, Ladkrating Plantation in Chachoengsao and Cha-am Teak Farm in Phetchaburi (Figure 4).

1. Teak International Provenance Trials, Teak Improvement Center, Ngao Lampang was established in 1974, at latitude 18° 40 N, longitude 99° 55 E and 350 m. a.m.s.l. The average minimum temperature is 18.5°C and the maximum is 32.2°C. The average annual rainfall is 1400 m. Soil type is Loamy-Clay. The experimental design used is Randomized Complete Block Design. The trials consists of 4 blocks, each block comprises 8 plots. There are 25 trees per plot planted with the spacing of 4X4 m. Seed sources were from a total of 8 provenances and three countries, one from Indonesia, three from India and four from Thailand. Details of seed sources are shown in Table 3 and Figure 5 and 6.

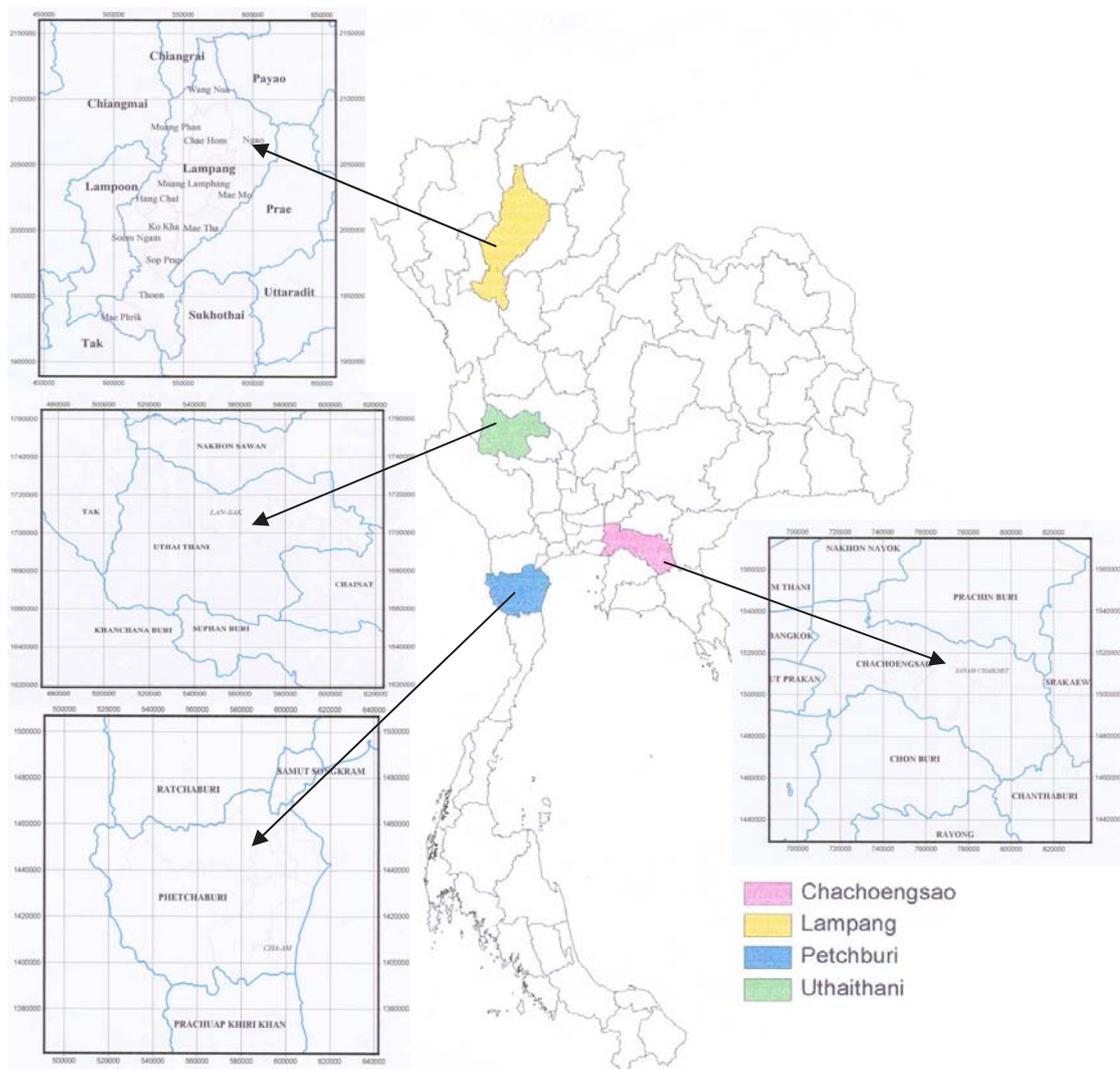


Figure 4 Location of all experimental sites in Thailand.

Table 3 Details of seed sources in the Teak International Provenance Trials established in Lampang in 1974

DFSC/TIC No.	Seed Sources	Lat/Long	Altitude (m)	Rainfall (mm)	Site
3049/100	Indonesia Ngliron	7° 12' S 111° 22' E	150	1200	
3002/108	India Kalkaz, Maharashtra	21° 30' N 77° 15' E	496	1638	Moist
3008/113	India Haliyal, Karnataka	15° 21' N 74° 52' E	610	1398	Dry
3013/116	India Arbail, Karnataka	14° 50' N 74° 41' E	690	2565	Very Moist
3039/129	Thailand, Tak Maekut Luang, Mae Sod	16° 49' N 98° 36' E	220	1644	
3041/130	Thailand, Chiangmai Mae Pam, Chiang Doa	19° 02' N 99° 02' E	450	1100-1200	
3043/132	Thailand, Phayao Doi Thon, Muang	19° 03' N 99° 03' E	562	1200	
-/133	Thailand, Lampang TIC SPA, Mae Huad, Ngao	18° 40' N 99° 55' E	350	1000	

Provenances 3002/108, 3008/113, 3013/116, 3039/129, 3041/130 and 3043/132 are selected from natural teak stands. Provenance 3049/100 is a teak landrace, whereas provenance -/133 is improved seed source from a seed production area.

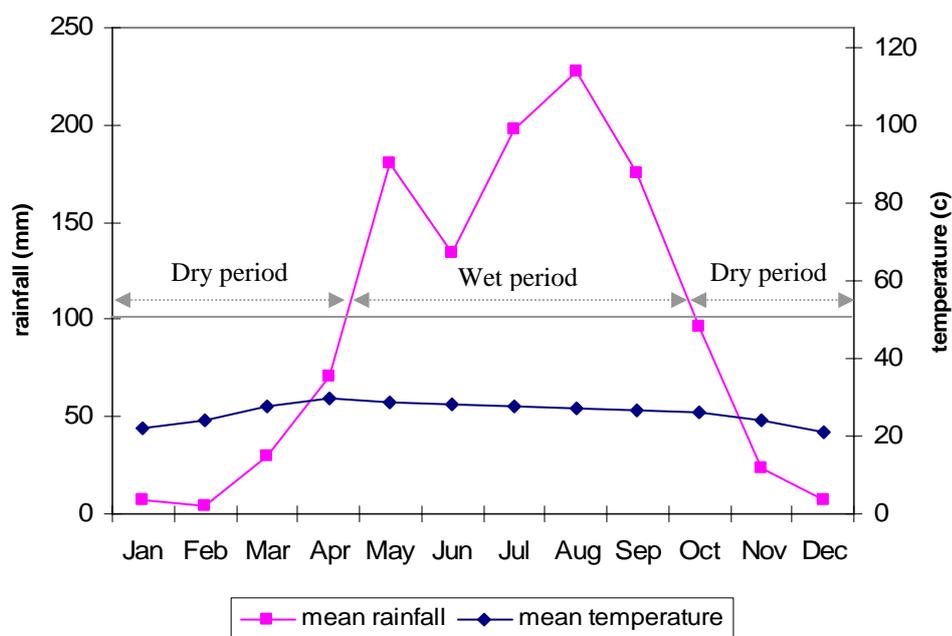


Figure 5 Climatic diagram of Teak Improvement Center, Ngao, Lampang, during 1975-2004.

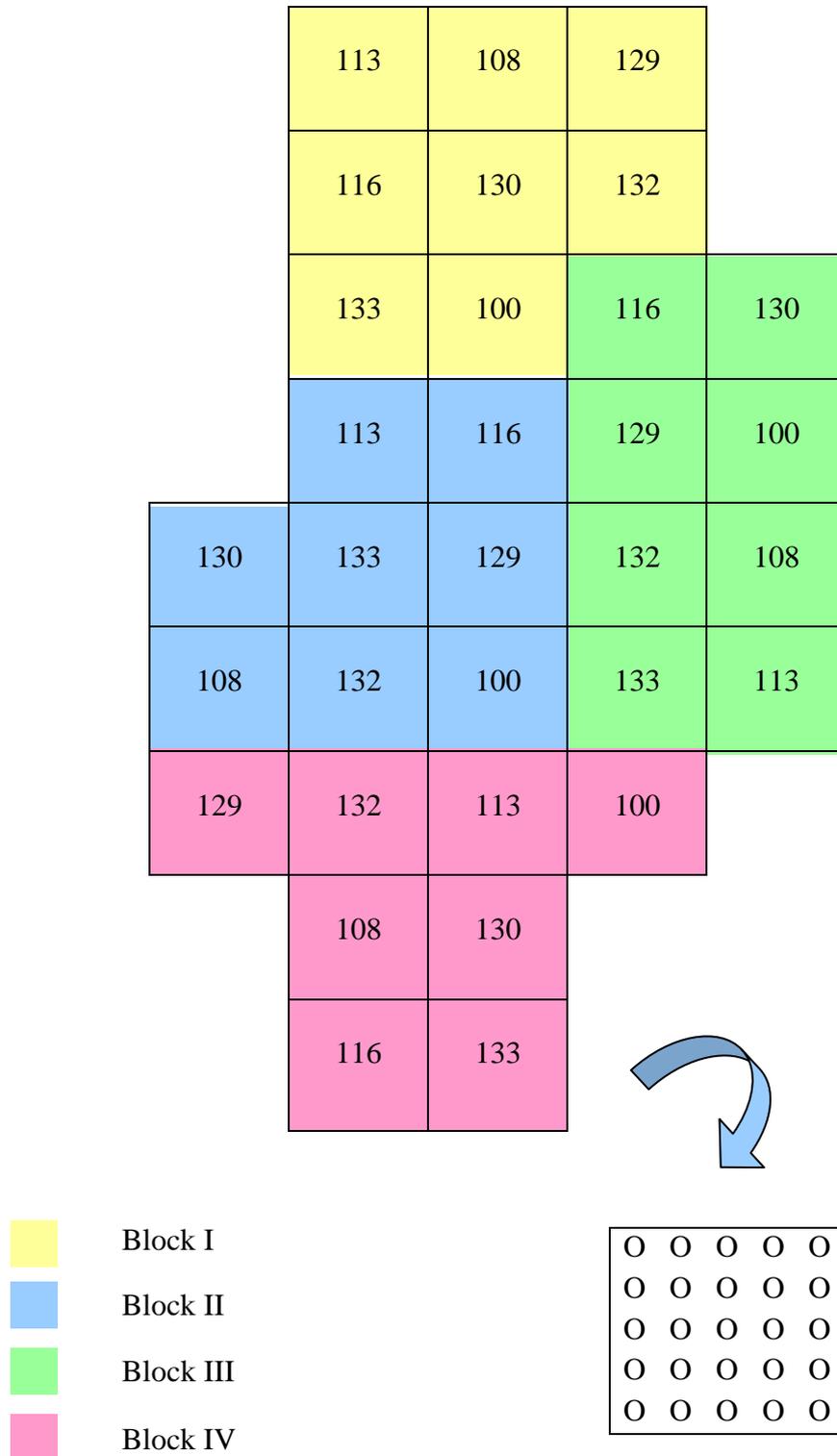


Figure 6 Lay out of Teak International Provenance Trials, consisting of 8 provenances, Ngao, Lampang.

2. TPC Seed Center in Uthai Thani

TPC Seed Center is located at Lansak district in Uthai Thani at the latitude 15° 25' N, longitude 99° 40' E and 85 meters above sea level. Soil texture consists of sand 45.32%, silt 26% and clay 28.34%. Temperature ranges between 21.8°C - 37°C with a mean of 27.7°C. Mean annual rainfall is 1260.9 mm. with a dry period from November to April (Figure 7). Soil type is coarse loamy, Siliceous, isohyperthermic Typic Ustifluent in the Tamuang Series (F/FRED, 1988). The study was carried out at Teak Clone Bank and Teak Clonal Seed Orchard at TPC Seed Center in Uthai Thani.

Teak Clone Bank was established in 1983, consisting of 71 clones 4 ramets each. Details of each clone are shown in Table 4. Four grafts of each clone were planted in systematic design with the spacing of 4 x 4 m. The lay out of Teak Clone Bank is shown in Figure 8. The planting size is 30 x 30 x 30 cm and 2 kg of manure was used in the bottom before planting. Weeding was done three times a year and NPK fertilizer was also applied at about 20 g per graft. Termite control is done by means of chemical treatment.

Teak Clonal Seed Orchard was established in 1986. The orchard comprises of 25 selected clones, which were screened from Teak Clone Bank after planting for three years. The orchard consists of 20 blocks and each block consists of a set of 25 selected clones. The orchard spacing used is 10 x 10 m. Randomize Complete Block Design (RCBD) was used, see Figure 9. The planting system was done in the same system as in the Teak Clone Bank. Weeding was also done three times a year.

3. Ladkrating Plantation, Chachoengsao

First Generation Clonal Seed Orchard, Ladkrating Plantation, Chachoengsao is located at latitude 13° 42' N, longitude 101° 06' E and 80 m above mean sea level. The temperature range between 22.9°C-33.9°C, with a mean temperature of 28.4°C. Mean annual rainfall is 1,305.3 mm. with a dry period from November to April. Soil type is clayey-skeletal, Kaolinitic, Aeric Kanhapustuit Series (F/FRED, 1988). The Teak Clonal Seed Orchard was established in October, 2002 by clones selected from Teak Clone Bank, Uthai Thani. The experimental design used is Randomized Complete Block Design (RCBD) and consist of 4 blocks, 25 clones each. The spacing used 8 X 8 m. The manure and polymer were applied in the early planting process. Detail of this experiment is shown in Table 5 and Figure 10 and 11.

Table 4 Details of clone origin in Teak Clone Bank established in TPC Seed Center, Uthai Thani in 1983

Plus Tree No.	Source of Origin	Stands	Year	Lat./Long.
V3	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V4	Lampang, Ngao, Chum Pui	Nat.	1959	18°30'N 98°45'E
V7	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V22	Lampang, Ngao, Huay Yien	Nat.	1965	18°45'N 100°00'E
V23	Lampang, Ngao, Huay Yien	Nat.	1965	18°45'N 100°00'E
V24	Lampang, Ngao, Mae Huad	Nat.	1965	18°45'N 100°00'E
V25	Lampang, Ngao, Mae Huad	Nat.	1965	18°45'N 100°00'E
V26	Lampang, Mae Moh	Nat.	1965	18°30'N 99°45'E
V27	Lampang, Muang, Ban Na Po Tai	Nat.	1965	18°15'N 100°00'E
V29	Lampang, Ngao, Mae Tib	Nat.	1965	18°30'N 100°00'E
V30	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V32	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V33	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V34	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V35	Phrae, Rong, Kwang Chom Pu	Plant.	1965	18°30'N 100°15'E
V36	Phrae, Den Chai	Nat.	1965	18°00'N 100°15'E
V37	Phrae, Den Chai	Nat.	1965	18°00'N 100°15'E
V38	Mae Hong Son, Mae Sariaeng, Dang Sangat	Nat.	1965	18°15'N 98°00'E
V39	Mae Hong Son, Mae Sariaeng, Mae Yom River	Nat.	1966	18°15'N 98°00'E
V40	Mae Hong Son, Mae Sariaeng, Ban Huay Luang	Nat.	1966	18°15'N 98°00'E
V41	Mae Hong Son, Mae Sariaeng, Mae Salath	Nat.	1966	18°15'N 97°45'E
V42	Phrae, Long, Ta-Pa-Mok	Nat.	1966	18°15'N 98°45'E
V43	Phrae, Ta-Pa-Mok, Huay Mae Suak	Nat.	1966	18°15'N 98°45'E
V45	Tak, Mae Soi, Huay Mae Bann	Nat.	1966	16°45'N 98°30'E
V46	Tak, Mae Sod, Ban Pop Pra	Nat.	1966	16°45'N 98°30'E
V49	Yala, Ban Wang	Plant.	1966	
V69	Sukothai, Tah Chai	Plant.	1966	17°00'N 100°00'E
V72	Lampang, Ngao, Mae Huad	Plant.	1967	18°45'N 100°00'E
V73	Lampang, Ngao, Mae Huad	Plant.	1943	18°45'N 100°00'E
V74	Lampang, Ngao, Ban Tak	Nat.	1967	18°45'N 100°00'E
V76	Lampang, Muang Mang Taun For	Nat.	1967	18°15'N 99°30'E

Table 4 (continued)

Plus Tree No.	Source of Origin	Stands	Year	Lat./Long
V78	Lampang, Ngao, Pleung Nong Ton	Nat.	1967	18°45'N 100°00'E
V79	Phrae, Mae Jua	Plant.	1968	18°00'N 100°00'E
V80	Phrae, Long, Mae Jum	Nat.	1968	18°15'N 98°15'E
V81	Phrae, Den Chai	Nat.	1968	18°00'N 100°15'E
V83	Sukothai, Tah Chai	Plant.	1958	17°00'N 100°00'E
V84	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V85	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V86	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V88	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V89	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V90	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V92	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V93	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V95	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V96	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V97	Phrae, Mae Phuak	Plant.	1969	17°00'N 100°00'E
V98	Phrae, Huay Rai	Plant.	1969	18°00'N 100°00'E
V99	Phrae, Mae Bai	Plant.	1969	18°00'N 100°00'E
V100	Phrae, Mae Bai	Plant.	1969	18°00'N 100°00'E
V110	Lampang, Ngao, Mae Huad	Plant.	1978	18°45'N 100°00'E
V111	Lampang, Ngao, Mae Huad	Plant.	1978	18°45'N 100°00'E
V112	Lampang, Ngao, Mae Huad	Plant.	1978	18°45'N 100°00'E
V113	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V114	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V115	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V116	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V117	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V118	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V119	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V120	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V121	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V122	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V123	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V124	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V126	Phrae, Long	Plant.	1979	18°00'N 99°40'E
V127	Phrae, Long	Plant.	1979	18°00'N 99°40'E
V128	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V129	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V130	Phrae, Long	Plant.	1979	18°00'N 99°45'E

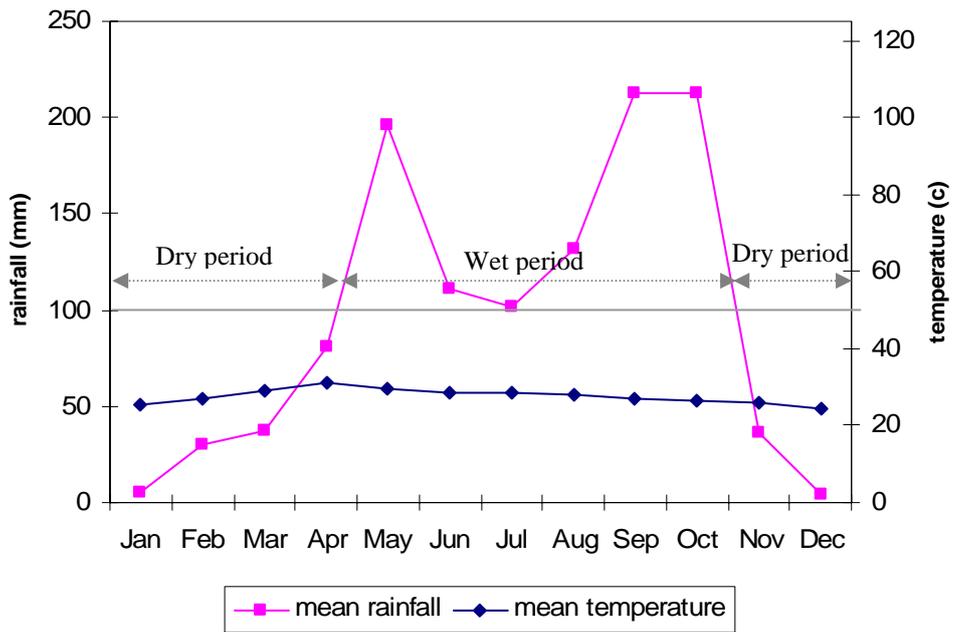


Figure 7 Climatic diagram of Lansang, Uthai Thani, during 1983-2003.

V23	V24	V34	V35	V45	V46	V80	V81	V93	V95	V113	V114	V123	V124	
V22	V25	V33	V36	V43	V49	V79	V83	V92	V96	V112	V115	V122	V126	
V7	V26	V32	V37	V42	V69	V78	V84	V90	V97	V111	V116	V121	V127	
V4	V27	V30	V38	V41	V72	V76	V85	V89	V98	V110	V117	V120	V128	
V3	V28	V29	V39	V40	V73	V74	V86	V88	V99	V100	V118	V119	V129	V130

●	V3/4
●	V3/3
●	V3/2
●	V3/1

Figure 8 Experimental design of Teak Clone Bank, TPC Seed Center, Uthai Thani.

30	128	73	83	36	72	34	111	121	32	127	110	32	111	99	128	99	32	110	37	32	111	110	36	100
110	72	43	49	111	35	26	99	112	130	35	119	37	121	100	119	120	3	45	26	128	3	34	43	120
32	26	3	121	37	49	119	100	127	120	112	45	34	73	49	111	72	49	36	84	112	84	119	73	130
45	84	35	100	119	83	73	36	37	128	26	120	36	83	130	127	100	112	34	35	127	49	121	26	37
120	99	127	112	34	84	43	3	110	45	128	72	43	34	3	83	43	130	73	121	45	99	72	35	83
49	37	3	73	128	119	128	100	32	45	127	73	111	83	32	111	34	36	84	43	111	32	100	43	112
112	100	127	32	130	99	26	111	83	3	110	49	99	36	112	32	3	37	35	119	34	127	120	110	45
119	36	121	34	43	36	72	130	121	34	34	84	43	26	119	127	130	112	45	121	49	35	83	130	128
72	120	45	111	26	112	84	73	127	43	100	3	121	45	130	73	110	83	99	100	84	99	119	121	3
83	84	99	35	110	35	49	110	37	120	120	72	128	37	35	49	72	120	26	28	73	37	26	72	36
49	130	128	120	110	119	32	128	49	72	49	35	83	112	84	35	72	26	111	100	3	43	34	84	119
32	112	3	83	73	127	45	37	120	100	73	111	127	130	110	127	36	120	119	37	73	32	121	100	37
100	99	121	111	72	130	84	36	121	35	45	43	72	100	99	3	45	34	83	73	99	45	49	120	127
43	34	45	37	26	73	43	112	34	111	120	3	26	36	37	112	43	32	121	49	128	36	83	72	130
84	35	127	119	36	3	110	99	83	26	121	34	128	32	119	99	84	130	110	128	35	112	110	111	26
3	45	72	110	111	112	120	37	3	43	100	127	36	110	73	37	49	127	128	112	121	110	73	36	45
37	84	43	112	120	72	128	34	36	26	32	128	49	34	99	84	111	32	121	99	111	83	127	26	119
100	83	32	127	36	130	127	84	110	121	43	26	37	84	72	130	35	45	36	3	120	100	34	130	37
121	119	26	130	128	83	111	99	73	119	35	130	83	45	111	110	83	72	34	119	49	72	43	32	112
73	35	99	34	49	32	45	49	35	100	119	112	121	120	3	100	73	43	26	120	99	84	35	128	3

Figure 9 Experimental design of Teak Clonal Seed Orchard, TPC Seed Center, Uthai Thani.

Table 5 Scions were collected from TK Teak Clone Bank, Uthai Thani

Plus Tree No.	Source of Origin	Stands	Year	Lat./Long
V3	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V7	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V33	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V34	Lampang, Ngao, Mae Huad	Plant.	1965	18°45'N 100°00'E
V36	Phrae, Den Chai	Nat.	1965	18°00'N 100°15'E
V39	Mae Hong Son, Mae Sariaeng, Mae Yom River	Nat.	1966	18°15'N 98°00'E
V40	Mae Hong Son, Mae Sariaeng, Ban Huay Luang	Nat.	1966	18°15'N 98°00'E
V41	Mae Hong Son, Mae Sariaeng, Mae Salath	Nat.	1966	18°15'N 97°45'E
V42	Phrae, Long, Ta-Pa-Mok	Nat.	1966	18°15'N 98°45'E
V45	Tak, Mae Soi, Huay Mae Bann	Nat.	1966	16°45'N 98°30'E
V46	Tak, Mae Sod, Ban Pop Pra	Nat.	1966	16°45'N 98°30'E
V49	Yala, Ban Wang	Plant.	1966	
V69	Sukothai, Tah Chai	Plant.	1966	17°00'N 100°00'E
V74	Lampang, Ngao, Ban Tak	Nat.	1967	18°45'N 100°00'E
V76	Lampang, Muang Mang Taun For	Nat.	1967	18°15'N 99°30'E
V84	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V88	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V90	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V96	Sukothai, Tah Chai	Plant.	1968	17°00'N 100°00'E
V100	Phrae, Mae Bai	Plant.	1969	18°00'N 100°00'E
V111	Lampang, Ngao, Mae Huad	Plant.	1978	18°45'N 100°00'E
V118	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V124	Phrae, Long	Plant.	1979	18°00'N 99°45'E
V127	Phrae, Long	Plant.	1979	18°00'N 99°40'E
V130	Phrae, Long	Plant.	1979	18°00'N 99°45'E

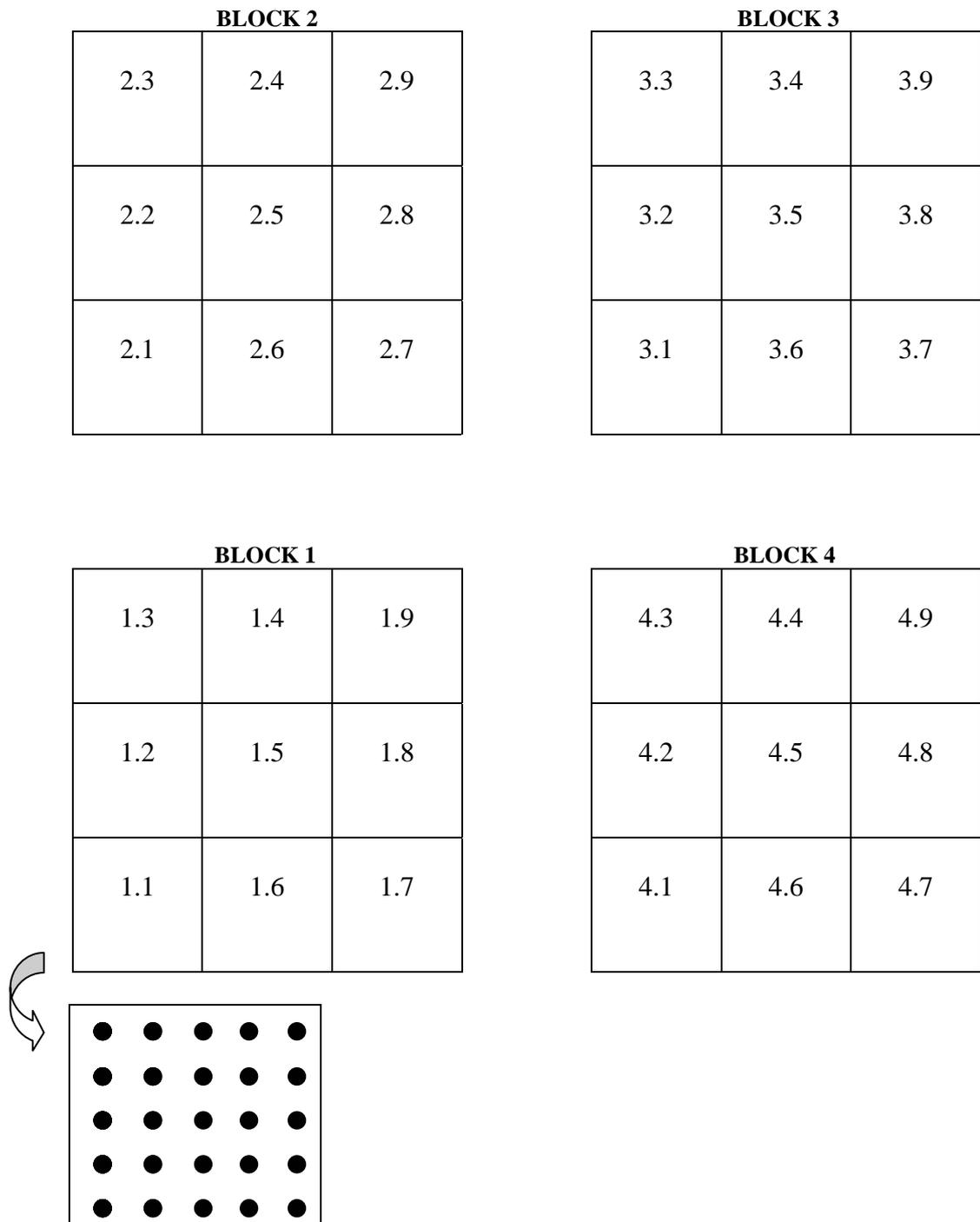


Figure 10 First Generation Clonal Seed Orchard, Ladkrating Plantation, Chachoengsao.

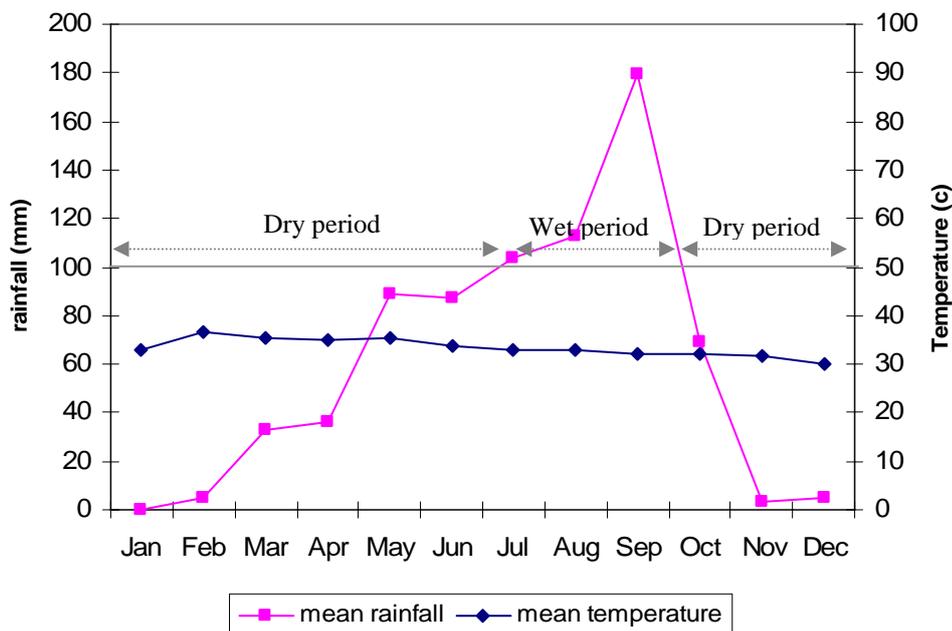


Figure 11 Climatic diagram of Ladkrating plantation, Chachoengsao, during 2000-2005.

4. Cha-am Teak Farm, Phetchaburi

Cha-am Teak Farm is a private tree farm area located at Huay Sai Nuar Subdistrict, Cha-am district, Phetchaburi province. The site is located at latitude 12° 40' and longitude 99° 50'. The temperature ranges between 14.7° -37.5°C, with a mean temperature of 27.5°C. Mean annual rainfall ranges between 849.99-1,332.1 mm. with the number of raining day ranging between 93-129 days. Soil is loamy sand and the site was used in cassava planting for a number of years. In 1994, teak plantation and the experiment were established in this area. Detail on this plantation site is shown in Figure 12 and 13.

Materials used in this experiment consists of seedling arised from tissue culture of plus tree Nos. 3 and 33 with comparison to stumps originated from Mae Tip Seed Production Area and from Lampang natural seed sources.

In this experiment, teak stumps from Mae Tip Seed Production Area were supplied by the Teak Improvement Center in Lampang and stumps from natural forest in Lampang were supplied by Lampang Regional Forest Office. The stumps used had the standard size of 1 cm diameter at root collar. Whereas, Tissue culture materials were prepared by Thai Orchid Co. based on the clonal materials screened by Teak Improvement Center. The seedlings were transplanted into black polyethylene bag and kept under green house condition. Seedlings were later on transferred to

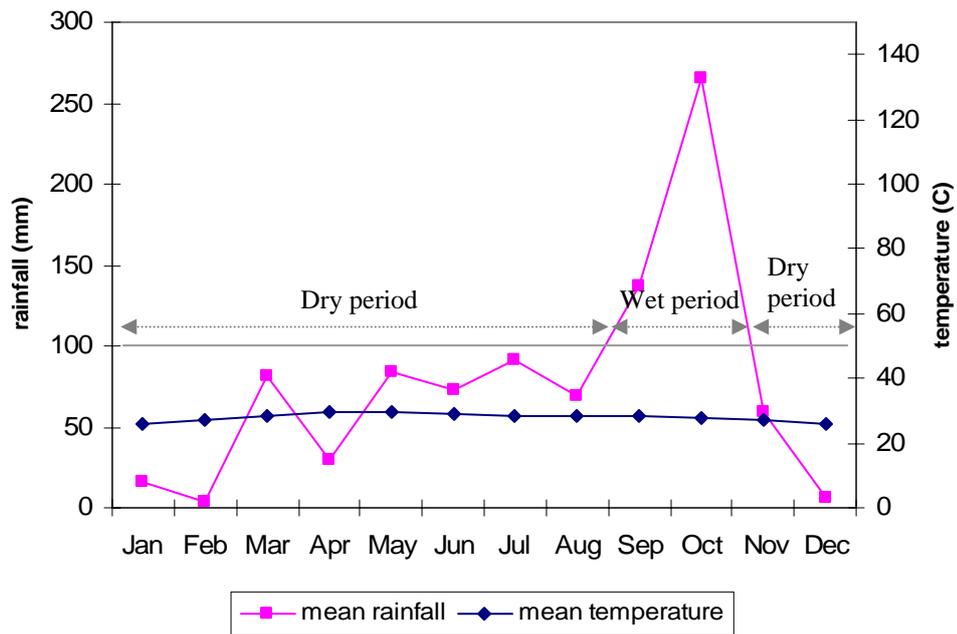


Figure 13 Climatic diagram of Cha-am Teak Farm, Phetchaburi, during 1994-2004.