

### Clone Bank

The survival percentage of these clones in an early stage was previously reported by Pudaeng (1985). Even though most clones had 100% survival percentage, some the poor clones had only 50%. The survival percentage relied very much on the grafting techniques and the adaptation of clones to the new environment. It was found that each clone showed differences in the success in grafting. As clones grew older, other biotic enemies, particularly termites, were also found to affect some clones in the dry season. Chemical control of termites was then applied to most grafts to ensure the normal development of each clone.

In the same experiment, Jaijing (1994), studied the survival percentage of 8 years old teak clones. It showed that about 65.6% of all clones had 100% of survival. In the later years, some clones had poor survival percentage. This was due to biotic enemies and long drought in 1990. Evermore, a heavy storm also caused top cut to some grafts. Otherwise, this study showed the poor decision to select *E. deglupta* for the shelterbelt except where the rows were planted at narrow spacing.

#### **1. Survival Percentage**

In the present study covered 71 clones planted in form of clone bank at TPC Seed Center, Uthai Thani was investigated when the clonal materials were 19 years old. At least 5 groups of clones could be classified as far as the survival percentage is concerned. It was found that the survival percentage varied from 0 to 100%, 47 out of 71 clones had 100% of survival with the average survival of 87.85%. The clone V78 and V95 had low survival percentage (25%) while only clone V79 and V97 had died all (Table 16). Moreover inferior clones (**V78**, **V95**, **V79** and **V97**) should not be used for planting in this site or neighborhood. It's not only they can nor tolerance to biotic and abiotic enemies but they also can not adapted and fitted to this planting sites

**Table 16** Variation survival percentages of teak in the Clone Bank, established in Uthai Thani in 1983 (19 years old)

Survival percentages	Clones	Total
100	V3, V4, V24, V25, V26, V28, V29, V32, V34, V35, V36, V37, V40, V44, V43, V45, V49, V74, V76, V80, V81, V85, V86, V90, V92, V93, V96, V98, V99, V100, V110, V112, V113, V114, V116, V117, V118, V120, V121, V122, V123, V124, V126, V127, V128, V129, V130	47
75	V7, V22, V23, V27, V30, V38, V42, V46, V69, V73, V83, V88, V89	13
50	V33, V39, V72, V84, V111, V115, V119	7
25	V78, V95	2
0	V79, V97	2
Grand total		71

## **2. Height Growth**

As regards to height growth performances of these teak clones, it was found that the relationship on height growth was relatively small between juvenile and mature stages. Ranking of priority clones changed greatly when the reassessment was done at the ages of 3, 6, 9, 12, 15, 96, 180 and 228 months (Table 17). Results indicated that it was better to justify for superior clone selection in the maturity or at least it should reach to its half rotation.

Clonal variation on height growth in Clone Bank, Uthai Thani were previously studied and reported that grafts at the ages of 6, 12 and 18 months old have the average height of 2.02 m, 3.29 m and 5.02 m respectively. At the age of 3 months, the promising clones for height growth were V118, V121, V99, V130 and V128. When measured at the age of 6, 9, 12, 15 and 18 months, the ranking of priority trees changed greatly. The best clones in that period were V130, V100, V3, V45 and V121 respectively (Pudaeng, 1985 and Jaijing, 1994).

At 96 months, clonal variation on height growth changed considerably and thus the priority list indicated the following best clones are V45, V34, V43, V22, V118, V33 and V127. It could conclude that the height increment of these superior clones varied at different ages. It is thus very important to note that teak information in the early period of growth should be used carefully in order to select these clones for any planting program. In the better way, tree selection should be done when tree get mature. However, the justification should not be done by only using height performance but other tree parameters are also needed to consider.

At the age of 19 years, dominant clones based on height performance were **V34, V127, V36, V100** and **V74**. The total average height growth was found to be 19.64 m. ranging from 8.75 m (clone V110) to 24.55 m (clone V34).

## **3. Diameter at 10 cm above ground level ( $D_{10}$ )**

Diameter at ground level in each clone of teak is one of the important characters in selection for seed orchard establishment. Pudaeng (1985) reported that clones V118, V38, V69, V36, V37 and V122 were the best clones as top five priorities listed in diameter growth at ground level at the early stage of development. Clone V118 was still dominant in diameter growth at the ages of 6 months, 9 months, 12 months, 15 months and 18 months. The variation on diameter growth at ground level observed in several years of observation changed greatly in priority.

Jaijing (1994) studied growth at the age of 96 months old teak, it was found that clones V7, V84, V100, V118 and V34 showed the good performances in diameter at ground level.

In the present study, the diameter at 10 cm above ground level of 19 years old teak in clone bank was observed and measured. It was showed that  $D_{10}$  ranged from 11.26 cm (clone V86) to 38.15 cm (clone V100) with the overall average value of

**Table 17** Differences on height growth of 25 superior teak clones in various ages in the Teak Clone Bank, established in Uthai Thani in 1983 (19 years old)

Average height of superior clones in various ages (m)									
Priority	3 months	6months	9 months	12 months	15 months	18 months	96 months	180 months	228 months
1	V118 (1.858)	V118 (5.888)	V46 (2.963)	V130 (4.613)	V45 (6.258)	V45 (6.900)	V45 (17.800)	V34 (21.425)	V34 (24.55)
2	V121 (1.848)	V121 (5.838)	V3 (2.788)	V118 (4.313)	V130 (5.750)	V130 (6.458)	V34 (17.600)	V7 (20.167)	V127 (24.35)
3	V99 (1.818)	V130 (5.500)	V37 (2.743)	V45 (4.313)	V100 (5.750)	V100 (6.413)	V43 (17.400)	V49 (19.925)	V36 (24.10)
4	V130 (1.768)	V38 (5.263)	V118 (2.738)	V3 (4.186)	V42 (5.463)	V3 (5.975)	V22,118 (17.100)	V36 (19.600)	V100 (24.05)
5	V128 (1.755)	V69 (5.225)	V100 (2.700)	V37 (3.975)	V3,118 (5.413)	V121 (5.900)	V33,127 (16.800)	V111 (19.350)	V74 (23.48)
6	V100 (1.748)	V100 (5.175)	V40 (2.675)	V46 (3.963)	V128 (5.395)	V26 (5.825)	V124 (16.600)	V128 (19.300)	V45 (23.35)
7	V37 (1.723)	V36 (5.160)	121 (2.650)	V100 (3.913)	V110 (5.388)	V110 (5.788)	V7,36,100 (16.500)	V124 (19.250)	V122,128 (23.30)
8	V126 (1.703)	V43 (5.125)	99 (2.580)	V121 (3.863)	V121 (5.325)	V37 (5.740)	32,39,42 (16.300)	V112 (19.100)	V39 (23.25)
9	V84 (1.695)	V126 (2.418)	V84 (2.563)	V99 (3.850)	V120 (5.313)	V120 (5.738)	V49,96,113 (16.100)	V24 (18.925)	V41 (23.23)
10	V119 (1.660)	V3 (2.325)	V116 (2.513)	V42 (3.838)	V127 (5.263)	V99 (5.713)	V28,118 (16.000)	V74,113 (18.750)	V40 (22.98)
11	123 (1.658)	69 (2.300)	130 (2.488)	V32 (3.750)	V26 (5.250)	V46 (5.625)	V112,128 (15.900)	V42 (18.667)	V124 (22.65)
12	V112 (1.640)	V119 (2.275)	V126 (2.450)	V84 (3.738)	V32,99 (5.125)	V84 (5.613)	V25,80 (15.800)	V72,45 (18.650)	V116 (22.43)
13	V129 (1.633)	V128 (2.268)	V45,128 (2.400)	V129 (3.713)	V37 (5.100)	V118 (5.563)	V46 (15.700)	V32,39 (18.600)	V112 (22.35)
14	V45 (1.620)	V123 (2.238)	V43 (2.380)	V110 (3.650)	V84 (5.075)	V128 (5.550)	V24,26,41,122 (15.600)	V130 (18.500)	V49 (22.25)

Table 17 (continued)

Average height of superior clones in various ages (m)									
Priority	3 months	6months	9 months	12 months	15 months	18 months	96 months	180 months	228 months
15	V43,46 (1.618)	V129 (2.235)	V69 (2.363)	V128 (3.638)	V34 (4.938)	V34,42 (5.525)	V38,40,78,114 (15.500)	V43 (18.475)	V24 (22.18)
16	V32,40 (1.610)	V120 (2.213)	V119,123 (2.350)	V119,126 (3.613)	V129 (4.930)	V127 (5.425)	V93 (15.400)	V40,41 (18.375)	V111 (22.15)
17	V84 (1.695)	V126 (2.418)	V84 (2.563)	V99 (3.850)	V120 (5.313)	V120 (5.738)	V49,96,113 (16.100)	V24 (18.925)	V42 (22.10)
18	V119 (1.660)	V3 (2.325)	V116 (2.513)	V42 (3.838)	V127 (5.263)	V99 (5.713)	V28,118 (16.000)	V74,113 (18.750)	V43 (21.95)
19	V122 (1.528)	V114 (2.180)	V114 (2.300)	V116 (3.488)	V74 (4.800)	V111 (5.234)	V92 (14.900)	V122 (18.075)	V83 (21.87)
20	V120 (1.515)	V127 (2.169)	V76 (2.293)	V35 (3.475)	V43 (4.788)	V4,129 (5.225)	V129 (14.800)	V22 (17.933)	V96 (21.85)
21	V38 (1.450)	V111 (2.160)	V127 (2.288)	V123 (3.438)	V40 (4.750)	V43 (5.150)	V37 (14.500)	V28 (17.900)	V115 (21.70)
22	V35 (1.445)	V73 (2.158)	V35 (2.285)	V120 (3.413)	V4 (4.738)	V74 (5.138)	V3 (14.400)	V120 (17.867)	V118 (21.63)
23	V74 (1.423)	V96 (2.138)	V96 (2.218)	V74 (3.400)	V35,126 (4.713)	V126 (5.050)	V121,27 (14.300)	V25 (17.850)	V4, 72 (21.60)
24	V114,115 (1.418)	V72,115 (2.135)	V72 (2.205)	V26 (3.363)	V123 (4.588)	V35 (5.000)	V123 (13.900)	V115,123 (17.750)	V22 (21.53)
25	V93 (1.400)	V39 (2.133)	V39 (2.200)	V69 (3.338)	V116 (4.575)	V40,123,124 (4.938)	V120 (13.700)	V96 (17.725)	V28 (21.50)

**Table 18** Differences on diameter at ground level of 25 superior teak clones in various ages in the Teak Clone Bank, established in Uthai Thani in 1983 (19 years old)

Average D <sub>10</sub> of superior clones in various ages (m)									
Priority	3 months	6months	9 months	12 months	15 months	18 months	96 months	180 months	228 months
1	V118 (3.550)	V118 (5.888)	V118 (6.125)	V130 (6.575)	V118 (9.299)	V118 (10.550)	V7 (27.200)	V49 (34.330)	V100 (38.15)
2	V38 (3.238)	V121 (5.838)	V130 (5.750)	V118 (6.488)	V130 (9.038)	V130 (10.175)	V84 (27.000)	V100 (33.430)	V34 (38.05)
3	V69 (3.213)	V130 (5.500)	V37 (5.675)	V100 (6.238)	V26 (9.000)	V100 (9.950)	V100 (26.800)	V34 (32.010)	V118 (35.99)
4	V36,37 (3.188)	V38 (5.263)	V69 (5.475)	V3 (6.213)	V34 (8.700)	V121 (9.625)	V118 (26.700)	V7 (31.550)	V111 (35.85)
5	V122 (3.088)	V69 (5.225)	V3,119 (5.463)	V36 (6.175)	V121 (8.610)	V37 (9.525)	V34 (26.600)	V124 (31.390)	V124 (35.80)
6	V35 (3.063)	V100 (5.175)	V38 (5.448)	V37 (6.125)	V37 (8.375)	V3 (9.513)	V49,111 (26.500)	V111 (30.750)	V84 (35.45)
7	V43,130 (3.025)	V36 (5.160)	V121 (5.400)	V69 (6.075)	V36 (8.363)	V34 (9.363)	V46 (26.300)	V118 (30.560)	V3 (35.39)
8	V40 (3.013)	V43 (5.125)	V34 (5.388)	V38 (6.063)	V35 (8.275)	V36 (9.350)	V96 (25.500)	V3 (30.090)	V7 (35.38)
9	V84 (2.988)	V26 (5.113)	V100 (5.375)	V121 (6.050)	V40 (8.250)	V84 (9.288)	V84 (9.288)	V130 (29.980)	V74 (35.29)
10	V41,46 (2.950)	V46 (5.100)	V36 (5.300)	V26 (5.963)	V3,120 (8.213)	V26 (9.263)	V124 (24.900)	V36 (29.930)	V49 (35.13)
11	V83 (2.913)	V37 (5.063)	V46 (5.225)	V122 (5.850)	V42 (8.188)	V35 (9.088)	V69 (24.800)	V40 (29.550)	V130 (35.05)
12	V128 (2.900)	V83 (5.038)	V122 (5.200)	V46 (5.825)	V128 (8.163)	V43 (9.075)	V41,115 (24.700)	V41 (29.460)	V45 (34.84)
13	V29 (2.888)	V40 (5.000)	V42 (5.175)	V32 (5.775)	V69 (8.113)	V4 (9.063)	V36,114 (24.400)	V45 (29.410)	V41 (33.50)
14	V129 (2.875)	V124 (4.963)	V40 (5.038)	V34 (5.738)	V124,100 (8.063)	V45,124 (8.963)	V22,116 (24.300)	V84 (29.330)	V36 (32.51)

Table 18 (continued)

Average D <sub>10</sub> of superior clones in various ages (m)									
Priority	3 months	6months	9 months	12 months	15 months	18 months	96 months	180 months	228 months
15	V34,113 (2.863)	V35 (4.95)	V128 (5.000)	V42,43 (5.688)	V122 (8.050)	V128 (8.925)	V24 (24.000)	V38 (29.150)	V40 (32.30)
16	V26 (2.855)	V34 (4.938)	V43 (4.988)	V84 (5.663)	V49 (8.038)	V69 (8.913)	V122,129 (23.800)	V46 (28.97)	V42 (32.18)
17	V100,3999 (2.850)	V42,84 (4.900)	V35,116 (4.975)	V35 (5.650)	V99 (7.988)	V42,46,99 (8.850)	V4,40,121 (23.700)	V24 (28.93)	V39 (32.03)
18	V96 (2.788)	V128 (4.888)	V99 (4.963)	V40 (5.638)	V117 (7.963)	V117 (8.800)	V33,81,119 (23.600)	V39 (28.73)	V90 (30.86)
19	V76,124 (2.763)	V116,119 (4.875)	V41 (4.913)	V128 (5.613)	V38,43 (7.913)	V120 (8.738)	V26 (23.500)	V74 (28.160)	V38 (30.85)
20	V78,115116 (2.750)	V3,122 (4.850)	V26,49 (4.900)	V120 (5.600)	V4 (7.888)	V122 (8.713)	V28,130 (23.300)	V80 (28.140)	V96 (30.71)
21	V42,112 (2.725)	V99,117 (4.813)	V84,120 (4.863)	V49 (5.588)	V46 (7.850)	V49 (8.663)	V27,93 (23.100)	V69 (27.880)	V127 (30.66)
22	V74 (2.688)	V41 (4.738)	V124 (4.825)	V41 (5.575)	V45 (7.800)	V38 (8.650)	V113,128 (23.000)	V33 (27.280)	V28, 69 (30.58)
23	V120 (2.675)	V76 (4.725)	V123 (4.800)	V119 (5.563)	V32 (7.788)	V40 (8.600)	V45 (22.900)	V129 (27.240)	V129 (30.45)
24	V111,126 (2.650)	V126 (4.713)	V29,32 (4.788)	V45 (5.538)	V29,41 (7.775)	V41 (8.563)	V38,42 (22.800)	V116 (27.180)	V24 (30.41)
25	V32,43 (2.625)	V72 (4.688)	V115 (4.700)	V99 (5.513)	V72,123 (7.713)	V115 (8.55)	V25 (22.600)	V26 (27.110)	V126 (30.25)

27.87 cm. The dominant clones in  $D_{10}$  were clones **V100**, **V34**, **V118**, **V111** and **V124** with the average value of 38.15cm, 38.05cm, 35.99cm and 35.80 cm respectively (Table 18 ).

#### **4. Diameter at Breast Height (DBH)**

According to the previous study, at the age of 8 years old teak, Jaijing (1994) reported that there were 36 superior clones observed in the clone bank. Poor clones (clone V117 and V99) should be rejected in the future breeding program. The sequence of clones at the age of 8 years differed from the report by Pudaeng (1985) when the age of clones was 1 year.

In the present study DBH growth was also measured. The priority list of superior clones by using DBH growth still changed with age as shown in Table 19. At the age of 19 years old teak, it was found that DBH of these clones ranged from less than 10 cm (clone V85, V86, V97 and V99) to more than 25 cm. Clone **V100**, **V34**, **V84**, **V124** and **V130** showed the good performances on DBH with the value of 34.24, 32.70, 31.85, 31.24 and 31.13 cm respectively. However, DBH growth is also practically important in evaluating superior teak clones.

Table 17 showed the ranking of teak clones in height,  $D_{10}$  (Table 18), DBH (Table 19). Results showed that the evaluation at the early stages can be used temporary in determining suitable clones. Priority list was changed with ages and at the age closed to 20 years which is possible to harvest in teak tree farm, the accuracy in determining suitable clones was found. However, it is also interesting to study further whether the coppice of these clones performs similarly with ages in the next rotation.

#### **5. Tree Volume**

The present study, clonal variation in teak volume was also detected in clone bank as shown in Table 20. Average volume of 19 year-old teak clones varied from 0.06 m<sup>3</sup> per tree (clone V86) to 1.86 m<sup>3</sup> per tree (clone V100). Superior clones were clone **V100**, **V34**, **V130**, **V118**, **V124**, **V74**, **V39** and **V7**. Similarly, Jaijing (1994) noted that clone V3, V7, V22, V34, V46, V49, V100, V111 and V118 seem to be the best for selection in the future breeding program.

**Table 19** Clonal variation on DBH of 19 years old teak established in Uthai Thani in 1983

DBH (cm)	Clones	Total
> 25	V3, V7, V33, V34, V36, V39, V40, V41, V45, V49, V74, V84, V96, V100, V111, V116, V118, V124, V126, V127, V129, V130	22
24-25	V4, V38, V42, V90, V113, V128	6
23-24	V24, V32, V46, V23, V112, V115, V122	7
22-23	V28, V69, V78, V80, V81, V93, V121	7
21-22	V22, V25, V26, V27, V30, V76	6
20-21	V29, V37, V43, V72, V73, V95, V114, V123	8
19-20	V23, V88, V92, V119	4
18-19		-
17-18	V35, V120	2
16-17		-
15-16		-
10-15	V89, V98, V110, V117	4
< 10	V79, V85, V86, V97, V99	5
<b>Grand total</b>		<b>71</b>

**Table 20** Clonal variation on volume of 19 years old teak established in Uthai Thani in 1983

Average volume (m <sup>3</sup> /ramet )	Clones	Total
> 1.50	V34, V100, V130	3
1.0-1.5	V3, V7, V33, V36, V39, V40, V41, V42, V45, V49, V74, V84, V96, V111, V116, V118, V124, V126, V127, V128, V129	21
0.5-1.0	V4, V22, V23, V24, V25, V26, V27, V28, V29, V30, V32, V37, V38, V43, V46, V69, V72, V73, V76, V78, V80, V 81, V83, V88, V90, V92, V93, V95, V112, V113, V114, V115, V120, V121, V122, V123, ,	36
<0.5	V35, V79, V85, V86, V89, V97, V98, V99, V110, V117, V119	11
<b>Grand total</b>		<b>71</b>

## 6. Crown diameter growth

The development of crown form depends on the genetic background. Some tree breeder may prefer narrow tree crowns and selection criteria was set to meet such requirement. It was however aimed to plant more trees per unit area for more expected wood production. Beside the genetic background, spacing and age are also affects to crown diameter development.

Concerning to the study on crown diameter development of teak in the present study, average crown diameter of 19 years clones was 5.19 m, ranging from 3.05 m (clone V95) to 7.74 m (clone V130), as shown in Table 21. In general, any teak clones were planted with wider spacing, they will have great crown because of less disturbance and competition. Nevertheless in this study these clones were planted in closer spacing of 4 m. Spacing thus has also effect on crown development. Some dominant clones have effected in crown diameter development of the adjacent clones.

**Table 21** Differences on crown diameter of 19 years old teak clones established in Uthai Thani

Clones	Crown diameter (m)	Clones	Crown diameter (m)	Clones	Crown diameter (m)
V3	7.54	V45	4.88	V98	5.52
V4	6.49	V46	4.54	V99	5.46
V7	6.62	V49	5.57	V100	6.62
V22	5.70	V69	5.90	V110	4.71
V23	5.93	V72	4.28	V111	5.08
V24	5.43	V73	4.76	V112	4.30
V25	3.34	V74	5.13	V113	5.48
V26	5.03	V76	6.41	V114	4.31
V27	5.06	V78	6.10	V115	4.81
V28	4.76	V79	-	V116	6.31
V29	4.87	V80	5.18	V117	4.72
V30	4.79	V81	4.26	V118	6.44
V32	5.72	V83	5.98	V119	4.62
V33	4.60	V84	6.29	V120	4.25
V34	5.46	V85	4.60	V121	4.37
V35	3.26	V86	4.88	V122	4.04
V36	4.41	V88	6.08	V123	4.00
V37	4.03	V89	4.46	V124	4.11
V38	4.93	V90	6.59	V126	6.25
V39	6.81	V92	4.27	V127	5.00
V40	5.84	V93	5.53	V128	5.71
V41	6.51	V95	3.05	V129	6.15
V42	5.07	V96	5.11	V130	7.74
V43	3.78	V97	-	<i>Average</i>	<i>5.21</i>