

2. Clonal Seed Orchard, Ladkrating Plantation, Chachoengsao

Like most clonal seed orchards, superior clones will be selected for establishment. There is clonal seed orchard established in Chachoengsao province previously. However, several good clones in the clone bank in Uthai Thani were planted under plantation conditions in Ladkrating Plantation and these clones showed exceptionally good growth as comparing to the normal teak in Ladkrating Plantation. In this case, the information from teak clone bank in Uthai Thani can be used in establishing the new seed orchard in ladkrating Plantation since the altitude and topography of the two site are comparable.

TPC has established the new teak clonal seed orchard in Ladkrating Plantation. The new seed orchard comprised of 25 superior clones selected from teak clone bank. The budding work was done in TPC Seed Center in Uthai Thani in 2001. It was found that trained personnel left the center and only one remain to do the job. This is the common problems in most tropical countries that the training should be repeated so that we can keep the trained personnel in the program. Two years old teak root stocks were used in the budding work. The success of teak budding work varies from clone to clone, ranging from 20-80%. In this case, we need more rootstocks and more teak buds. Fortunately, the materials are available at the site and clone bank can provide sufficient buds for the work. All successful budded materials were transferred to Ladkrating Plantation Nursery for adaptation to a new climatic condition and for hardening work prior to the planting.

Materials were planted in the field formerly the provenance trials of *Acacia mangium* and has tremendous amounts of nodules were left over and make the area more fertility. Planting system used is the Randomized Complete Block Design with the spacing of 12 m. At this long planting distance, it will generate more crown development and so as to keep the stem quality of teak ramets and to make use of land economically by planting *Acacia mangium* surrounding the teak ramets. This multipurpose tree will be harvested in the early stage for fiber board industry. The survival percentage and the early development of teak ramets are as follows:-

2.1 Survival Percentage

Generally, the survival percentage of tropical trees under plantation conditions varies considerably, depending on tree adaptation, damages caused by biotic agents or forest fire, site condition, and other environmental factors. Similarly, teak clone when planted under seed orchard condition showed the variation in survival percentages. It was observed in Uthai Thani that the variation was also found among ramets of the same clones.

In the present study, the survival percentage of 1, 6, 9, 12, 15 and 18 months old teak clones were ranged between 77.77-100, 61.11-88.88, 52.77-88.88, 50.00-86.11, 50.00-86.11 and 47.22-83.33% respectively. And the average value of survival percentage of these clones in each ages were 93.77, 76.00, 74.55, 71.33,

Table 42 Survival percentage of 25 teak clones at several months in Teak Clonal Seed Orchard, Ladkrating Plantation, Chachoengsao

Clones	Average survival percentage at the age of					
	1 month	6months	9 months	12 months	15 months	18 months
V3	94.44	77.77	77.77	77.77	77.77	66.66
V7	94.44	80.55	80.55	77.77	77.77	72.22
V33	88.88	75.00	75.00	72.222	72.22	69.44
V34	100	80.55	80.55	80.55	80.55	75.00
V36	97.22	77.77	77.77	72.22	72.22	66.66
V39	91.66	77.77	75.00	72.22	72.22	63.88
V40	72.22	61.11	61.11	61.11	55.55	47.22
V41	97.22	66.66	66.66	63.88	63.88	61.11
V42	97.22	77.77	72.22	66.66	66.66	63.88
V45	94.44	88.88	88.88	86.11	83.33	83.33
V46	75.00	52.77	52.77	50.00	50.00	50.00
V49	97.22	69.44	66.66	58.33	58.33	50.00
V69	97.22	83.33	77.77	69.44	69.44	58.33
V74	97.22	77.77	77.77	75.00	75.00	72.22
V76	97.22	83.33	80.55	80.55	77.77	75.00
V84	94.44	72.22	72.22	72.22	72.22	69.44
V88	94.44	61.11	61.11	58.33	55.55	55.55
V90	94.44	83.33	83.33	80.55	80.55	80.55
V96	100.00	86.11	86.11	86.11	86.11	83.33
V100	100.00	80.55	80.55	75.00	75.00	72.22
V111	100.00	72.22	72.22	61.11	58.33	58.33
V118	97.22	83.33	77.77	72.22	72.22	72.22
V124	97.22	75.00	72.22	66.66	63.88	55.55
V127	77.77	61.11	61.11	61.11	61.11	55.55
V130	97.22	94.44	86.11	86.11	86.11	83.33
Total average	93.77	76.00	74.55	71.33	70.55	66.44

Table 43 Analysis of variance on survival percentage of teak in Teak Clonal Seed Orchard, established in 2002, Ladkrating Plantation, Chachoengsao

1 month				
Source of Variation	df	SS	MS	F
Block	3	2926.944	975.648	6.731**
Clones	24	3548.165	147.840	1.020 ^{ns}
Error	72	10436.970	144.958	
6 months				
Source of Variation	df	SS	MS	F
Block	3	3716.849	1238.950	5.307**
Clones	24	8278.212	344.926	1.478 ^{ns}
Error	72	16807.404	233.436	
12 months				
Source of Variation	df	SS	MS	F
Block	3	6543.097	2181.032	7.999**
Clones	24	8932.498	372.187	1.365 ^{ns}
Error	72	19630.842	272.651	
15 months				
Source of Variation	df	SS	MS	F
Block	3	6334.743	2111.581	8.051**
Clones	24	9690.998	403.792	1.540 ^{ns}
Error	72	18882.874	262.262	
18 months				
Source of Variation	df	SS	MS	F
Block	3	3896.442	1298.814	4.305**
Clones	24	11167.643	465.318	1.542 ^{ns}
Error	72	21724.775	301.733	

^{ns} = Non-significant

**= High significant at the 99% of confidence limit

70.55 and 66.44% (Table 42). This result obviously showed that the survival rate in all clones varied accordingly. However, when teak clones planted were older, the difference in survival rate of each clone can be observed.

From the Table 43, Analysis of Variance on survival percentage, it was found that difference among clones was insignificant.

Generally, when teak clones grow older they are faced with long length of climatic conditions and facing with various biotic and abiotic enemies during the course of development. From this study, the results indicated that the survival percentage in this site varies from clone to clone. In the first period, all clones had high survival rate and deceased afterward as caused by the differences in adaptation to site and resistance to biotic injures. Moreover, the long drought period has effected the water deficit at the planting site and drought condition occurred and affected the normal development of teak ramets of all clones.

2.2 Height growth

In the early stages of ramet development, trees generally developed better height growth than diameter growth. Tree of various ages attained height growth differently and the differences in growth performances were also found even in trees of the same age (Wenger, 1995). Generally, the genetic background is one of the main factors influencing the growth and developing of tropic trees (Whitmore, 1975).

After planting ramets of 25 selected teak clones in the clonal seed orchard at Ladkrating Plantation, height growth of all ramets was recorded and evaluated. The total average height of 1,6,9,12,15 and 18 months teak were 0.175, 0.708, 1.332, 1.749, 1.802 and 2.256 cm respectively. Clone V3 showed the best growth performance on height. However, other clones expressed the good height performance. Difference on height character was slightly only 0.1-0.6 m (Table 44).

Based on Analysis of Variance on height growth, it was found that difference among clones was insignificant. This may be caused by the clone screening and all clones used one good clone. In contrast, high variation was found among blocks since 6 months old to 18 months old (Table 45).

2.3 Diameter at ground level (D_0)

In early development of ramets, this tree character of diameter at ground level is used to determine tree growth. In the present study, D_0 performance was studied on 1,6,9,12,15 and 18 months old teak in clonal seed orchard (Table 46) to be 0.854, 1.582, 2.474, 2.900, 3.154 and 3.318 cm respectively. Clone V40 expressed the highest value on D_0 growth.

The results of Analysis of variance showed that clone variation was insignificant but the highly significantly differences was observed among blocks (Table 47).

Table 44 Average height of 25 clones of teak at 1,6,9,12,15,18 and 24 months olds in Teak Clonal Seed Orchard at Ladkrating Plantation, Chachoengsao

Clones	Average Height (m) at the age of					
	1 month	6months	9 months	12 months	15 months	18 months
V3	0.092±0.039	0.831±0.362	1.459±0.615	2.103±0.796	2.191±0.822	2.518±0.855
V7	0.112±0.043	0.677±0.396	1.272±0.752	1.460±0.988	1.540±0.957	2.025±0.968
V33	0.076±0.030	0.803±0.332	1.554±0.561	1.931±0.845	2.073±0.878	2.583±0.880
V34	0.111±0.043	0.810±0.306	1.529±0.596	1.874±0.717	1.965±0.725	2.420±0.849
V36	0.164±0.042	0.551±0.257	1.066±0.551	1.366±0.653	1.448±0.665	1.915±0.855
V39	0.217±0.051	0.775±0.326	1.467±0.697	1.739±0.774	1.811±0.761	2.369±0.693
V40	0.160±0.057	0.737±0.411	1.454±0.809	1.875±1.078	1.951±1.013	2.353±1.054
V41	0.120±0.035	0.715±0.349	1.535±0.680	1.950±0.753	1.953±0.845	2.483±0.849
V42	0.139±0.042	0.575±0.281	1.188±0.449	1.777±6.682	1.498±0.664	2.116±0.581
V45	0.205±0.052	0.691±0.307	1.430±0.629	1.773±0.719	1.941±0.711	2.376±0.805
V46	0.170±0.066	0.767±0.383	1.326±0.619	1.862±0.848	2.001±0.875	2.310±0.866
V49	0.186±0.062	0.649±0.309	1.170±0.631	1.501±0.675	1.605±0.691	2.146±0.639
V69	0.241±0.066	0.721±0.333	1.419±0.652	1.676±0.789	1.795±0.824	2.115±0.901
V74	0.160±0.059	0.693±0.395	1.301±0.713	1.608±0.905	1.676±0.910	2.208±0.992
V76	0.163±0.041	0.602±0.366	1.198±0.664	1.567±0.777	1.644±0.809	2.076±0.800
V84	0.175±0.138	0.683±0.456	1.281±0.689	1.641±0.847	1.745±0.843	2.234±0.871
V88	0.175±0.078	0.728±0.294	1.100±0.649	1.546±0.743	1.713±0.738	2.023±0.882
V90	0.174±0.059	0.669±0.307	1.415±0.626	1.740±0.800	1.818±0.835	2.266±0.931
V96	0.188±0.056	0.690±0.200	1.236±0.453	1.723±0.573	1.896±0.623	2.266±0.773
V100	0.188±0.075	0.794±0.454	1.496±0.787	1.901±1.005	2.001±1.030	2.311±1.278
V111	0.211±0.085	0.611±0.277	1.035±0.551	1.450±0.764	1.621±0.715	1.999±0.979
V118	0.227±0.062	0.812±0.392	1.386±0.710	1.648±0.915	1.747±0.935	2.250±1.123
V124	0.234±0.062	0.586±0.266	1.214±0.556	1.564±0.763	1.703±0.757	2.159±0.934
V127	0.269±0.101	0.736±0.304	1.280±0.604	1.684±0.735	1.762±0.735	2.321±0.720
V130	0.209±0.059	0.792±0.347	1.421±0.616	1.769±0.800	1.859±0.807	2.427±0.900
Total average	0.175±0.078	0.708±0.344	1.332±0.647	1.749±1.510	1.802±0.818	2.256±0.891
CV(%)	44.57	48.58	48.57	86.33	45.39	39.49

Table 45 Analysis of variance on height performance of teak in Teak Clonal Seed Orchard, established in 2002, Ladkrating Plantation, Chachoengsao

1 month				
Source of Variation	df	SS	MS	F
Block	3	29.940	9.980	2.249 ^{ns}
Clones	24	2154.355	89.765	20.226**
Error	70	310.669	4.438	
6 months				
Source of Variation	df	SS	MS	F
Block	3	7801.396	2600.465	14.734**
Clones	24	5872.461	244.686	1.386 ^{ns}
Error	70	12354.972	176.500	
9 months				
Source of Variation	df	SS	MS	F
Block	3	2.514	0.838	11.923**
Clones	24	1.889	0.078	1.120 ^{ns}
Error	70	4.920	0.070	
12 months				
Source of Variation	df	SS	MS	F
Block	3	4.402	1.467	4.907**
Clones	24	6.133	0.256	0.855 ^{ns}
Error	70	20.930	0.299	
15 months				
Source of Variation	df	SS	MS	F
Block	3	3.079	1.026	8.577**
Clones	24	2.932	0.122	1.021 ^{ns}
Error	70	8.375	0.120	
18 months				
Source of Variation	df	SS	MS	F
Block	3	3.338	1.113	7.854**
Clones	24	2.793	0.116	0.822 ^{ns}
Error	70	9.918	0.142	

^{ns} = Non-significant

**= High significant at the 99% of confidence limit

Table 46 Average diameter at ground level (D_0) of 25 clones of teak at 1,6,9,12,15,18 and 24 months olds in Teak Clonal Seed Orchard at Ladkrating Plantation, Chachoengsao

Clones	Average D_0 (cm) at the age of					
	1 month	6months	9 months	12 months	15 months	18 months
V3	0.8472±0.266	1.6242±0.338	2.5262±0.295	2.9472±0.206	3.3160±0.306	3.3807±0.054
V7	0.8445±0.234	1.4978±0.261	2.2591±0.477	2.5554±0.395	2.7589±0.504	3.1107±0.494
V33	0.9131±0.270	1.6769±0.139	2.6774±0.329	3.0880±0.262	3.3489±0.338	3.4519±0.243
V34	0.9240±1.567	1.8592±0.141	2.8648±0.205	3.3521±0.254	3.7083±0.372	3.6242±0.366
V36	0.9386±0.301	1.3943±0.310	2.2133±0.634	2.4284±0.758	2.9145±0.905	3.1269±0.705
V39	0.9049±0.242	1.7335±0.263	2.4644±0.479	2.9769±0.787	3.2046±0.830	3.5335±0.565
V40	0.7441±0.208	1.8556±0.264	2.7758±0.334	3.2546±0.598	3.5304±0.259	3.6252±0.628
V41	0.7477±0.226	1.6070±0.278	2.4737±0.248	2.9336±0.419	3.3096±0.488	3.3909±0.312
V42	0.9992±0.244	1.4059±0.226	2.4095±0.372	2.7426±0.338	2.9107±0.422	3.2804±0.345
V45	0.7349±0.255	1.4361±0.294	2.3206±0.500	2.8500±0.652	3.0250±0.675	3.1875±0.674
V46	0.9186±0.200	1.6695±0.105	2.6419±0.150	3.1416±0.288	3.4769±0.255	3.4150±0.300
V49	0.9082±0.195	1.4367±0.221	2.5060±0.615	2.9543±0.550	3.2616±0.669	3.2194±0.777
V69	0.8458±0.263	1.6408±0.433	2.6086±0.669	3.0565±0.951	3.2526±0.827	3.3638±0.627
V74	0.8051±0.241	1.7119±0.324	2.3964±0.620	2.9741±0.613	3.1000±0.724	3.1774±0.732
V76	0.8683±0.241	1.4709±0.421	2.1893±0.404	2.6552±0.607	2.9273±0.625	3.4984±1.338
V84	0.8776±0.167	1.5651±0.394	2.4872±0.376	2.9116±0.408	3.1369±0.416	3.3822±0.439
V88	0.8686±0.246	1.5085±0.369	2.1618±0.845	2.5990±0.697	2.7421±0.838	2.9281±0.688
V90	0.9864±0.270	1.5902±0.108	2.4892±0.288	2.8970±0.337	3.1102±0.229	3.2550±0.252
V96	0.6137±0.227	1.5465±0.956	2.6006±0.096	2.9529±0.246	3.1244±0.411	3.3408±0.411
V100	0.8904±0.207	1.6636±0.438	2.5496±0.797	3.0154±0.816	3.2618±0.864	3.2892±0.504
V111	0.8674±0.229	1.3642±0.182	1.9908±0.416	2.4458±0.401	2.6594±0.514	2.8999±0.521
V118	0.7800±0.238	1.7198±0.425	2.7984±0.468	3.1242±0.486	3.3662±0.592	3.3984±0.427
V124	0.8059±0.263	1.4097±0.372	2.4954±0.529	3.0483±0.626	3.2255±0.707	3.5492±0.630
V127	0.9451±0.230	1.5875±0.350	2.3282±0.613	2.6942±0.572	2.9297±0.690	3.1663±0.473
V130	0.8053±0.258	1.6682±0.311	2.7544±0.267	3.0682±0.321	3.4332±0.473	3.4718±0.312
Total average	0.8548±0.404	1.5821±0.296	2.4746±0.471	2.9007±0.526	3.1544±0.579	3.3186±0.528
CV(%)	47.26	18.70	19.03	18.13	18.35	15.91

Table 47 Analysis of variance on D₀ performance of teak in Teak Clonal Seed Orchard, established in 2002, Ladkrating Plantation, Chachoengsao

1 month				
Source of Variation	df	SS	MS	F
Block	3	1.798	0.599	30.848**
Clones	24	0.761	0.031	1.633 ^{ns}
Error	70	1.379	0.019	
6 months				
Source of Variation	df	SS	MS	F
Block	3	1.940	0.647	9.384**
Clones	24	1.637	0.068	0.990 ^{ns}
Error	70	4.823	0.068	
9 months				
Source of Variation	df	SS	MS	F
Block	3	4.839	1.613	9.162**
Clones	24	4.099	0.171	0.970 ^{ns}
Error	70	12.425	0.176	
12 months				
Source of Variation	df	SS	MS	F
Block	3	7.500	2.500	9.279**
Clones	24	5.751	0.240	0.889 ^{ns}
Error	70	18.859	0.269	
15 months				
Source of Variation	df	SS	MS	F
Block	3	5.700	1.900	8.355**
Clones	24	4.851	0.202	0.889 ^{ns}
Error	70	15.920	0.227	
18 months				
Source of Variation	df	SS	MS	F
Block	3	4.765	1.588	5.862**
Clones	24	3.184	0.133	0.490 ^{ns}
Error	70	18.964	0.271	

^{ns} = Non-significant

**= High significant at the 99% of confidence limit

Result shows that these superior clones adapted similarly under Ladkrating Plantation. The variation among blocks would be indicated the need to improve the site fertility and drainage system which is sensitive to teak growth.

2.4 Diameter at Breast Height (DBH)

Even though growth characteristics of teak were measured since 1 month old, it was found that DBH at the early age could not be recorded as many teak clones had height growth less than 1.30 m. Thus the first measurement of DBH of teak clones initial at the age of one year.

Results indicate that less variation in DBH at all ages studied (Table 48). At the age of 12 months, the overall average DBH was 1.80 cm, ranging from 1.46 cm (clone V45) to 2.05 cm (clone V34). At 18 months, the overall average had increased slightly to 1.94 cm and varied from 1.59 cm (clone V45) to 2.26 cm (clone V40).

Analysis of variance on this performance of 12 and 18 months old teak was analyzed. It was found that variation occurred in both block and clone are insignificance with the exceptional case at the age of 18 months by which variation among blocks was found ($F=5.536^*$) (Table 49).

Table 48 Average diameter at breast height (DBH) of 25 clones of teak at 12 and 18 months olds in Teak clonal Seed Orchard at Ladkrating Plantation, Chachoengsao

Clones	Average DBH (cm) at the age of	
	12 months	18 months
V3	1.9558±0.275	2.1442±0.265
V7	1.6631±0.676	1.8047±0.468
V33	1.9955±0.408	2.2689±0.339
V34	2.0574±0.168	2.2055±0.256
V36	1.7813±0.334	2.0458±0.356
V39	1.7643±0.189	1.8427±0.435
V40	1.9958±0.355	2.2067±0.167
V41	1.8631±0.246	2.0970±0.226
V42	1.8344±0.420	1.6500±0.152
V45	1.4663±0.457	1.5979±0.485
V46	1.7232±0.171	1.9848±0.107
V49	1.7331±0.433	1.6990±0.456
V69	1.9295±0.280	2.1004±0.258
V74	1.8411±0.268	1.8313±0.279
V76	1.5234±0.318	1.6385±0.313
V84	1.9321±0.344	2.0060±0.246
V88	1.5448±0.342	1.7094±0.407
V90	1.7235±0.114	1.9660±0.157
V96	1.6694±0.246	1.7830±0.175
V100	1.9397±0.178	2.0371±0.347
V111	1.6513±0.279	1.9002±0.199
V118	2.0259±0.601	2.1101±0.548
V124	1.9052±0.365	2.1710±0.264
V127	1.7158±0.460	1.7900±0.452
V130	1.8563±0.228	1.9944±0.303
Total average	1.8034±0.344	1.9403±0.348
CV(%)	19.07	17.93

Table 49 Analysis of variance on DBH performance of teak in Teak Clonal Seed Orchard, established in 2002, Ladkrating Plantation, Chachoengsao

12 months				
Source of Variation	df	SS	MS	F
Block	3	0.765	0.255	2.185 ^{ns}
Clones	24	3.671	0.153	1.310 ^{ns}
Error	72	8.056	0.117	
18 months				
Source of Variation	df	SS	MS	F
Block	3	1.546	0.515	5.536*
Clones	24	3.608	0.150	1.615 ^{ns}
Error	72	6.515	0.093	

^{ns} = Non-significant

*= Significant at the 95% of confidence limit