

# Effect of scion wood maturity and time of grafting on the success, survivability and growth in cleft grafting of pummelo

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**Abstract:** The experiment was conducted at the "Germplasm Centre" (GPC) of the Fruit Tree Improvement Program (FTIP), Bangladesh Agricultural University, Mymensingh during March to August, 2013 to investigate the effect of scion wood maturity and time on the success, survivability and growth in cleft grafting of pummelo (BAU-1). The experiment consisted of two factors such as (i) three types of scion wood maturity viz., terminal, mid and basal portions of shoot used as scion and (ii) ten times of grafting operation viz., 28 March, each 12 and 28 of April, May, June, July and 12 August. The experiment was laid out in Randomized complete block design with three replications. Significant variations were observed in all parameters studied. In case of scion wood maturity, the minimum time required for bud breaking (23.59 days) and leaf opening (27.29 days), with the highest graft height (28.26 cm), number of branches per graft (2.83), number of leaves per graft (15.56), success (82.54%) and survivability (81.32%) were found in case of terminal portion used as scion but the maximum time required for bud breaking (24.08 days) and leaf opening (28.12 days), with the lowest graft height (27.49 cm), number of branches per graft (2.56), number of leaves per graft (13.97), success (81.39%) and survivability (79.84%) were found in case of basal portion used as scion. In respect of time of grafting operation, the lowest time was needed for bud breaking (23.04 days) and leaf opening (26.56 days) with the highest graft height (29.13 cm), number of branches per graft (3.52), number of leaves per graft (17.25), success (88.46%) and survivability (86.62%) when grafting operation was done on 12 May but the highest time was needed for bud breaking (24.77 days) and leaf opening (28.93 days), with the lowest graft height (26.43 cm), number of branches per graft (1.77), number of leaves per graft (11.76), success (75.62%) and survivability (73.89%) when grafting operation was done on 28 March. As regard to combined effect, the lowest time required for bud breaking (22.91 days) and leaf opening (26.30 days), with the highest graft height (29.68 cm), number of branches per graft (3.65), number of leaves per graft (18.25), success (88.90%) and survivability (87.87%) were found in case of terminal portion used as scion when the grafting operation was done on 12 May but the highest time required for bud breaking (25.06 days) and leaf opening (29.48 days), with the lowest graft height (26.15 cm), number of branches per graft (1.64), number of leaves per graft (11.50), success (74.60%) and survivability (72.67%) were found in case of basal portion used as scion when the grafting operation was done on 28 March.

**Key words:** Scion wood maturity, Time of grafting operation, Success, Survivability, Growth Performance, Pummelo.

## Introduction

Pummelo (*Citrus maxima* Merr.) belonging to the Rutaceae family, is one of the distinctive and easily recognized species of the genus Citrus. It is one of the most popular and commercially important minor fruits of Bangladesh and locally known as Batabi lebu or Jambura. It is propagated by both seed and vegetative means. The seedlings take about eight years to start blooming and yielding fruit but in grafted plant, fruits begin to appear after only two to three years (Anwaruddin and Sunarjono, 1987). Propagation by seed does not maintain true-to-type. Vegetative propagation will be identical to the tree from which scion is taken. Different methods of vegetative propagation like budding, grafting, layering etc. are in practice (Kains and McQuestion, 1958, Chattopadhyay, 1995 and Hartmann, *et al.*, 1997). But Cleft grafting being the modern method is reported to be widely and successfully practised all over Bangladesh. In Bangladesh grafting is carried out during the period from May to August with higher rate of success. For a graft union to be successful, it is necessary that temperature conditions during the periods of cellular activity, callus formation as well as during healing should be favorable (Parvin, 2013). The favorable temperature for cellular activity, in general, varies from 12°C to 35°C. The differentiation of callus into xylem and phloem is also decreased under reduced water potentials. The failure of union in grafting during winter months in Bangladesh is due to low temperature and low humidity in the atmosphere. Some research works have been done on various aspects of pummelo in different countries of the world including Bangladesh. But unfortunately literature regarding the effect of scion wood

maturity and time on the success, survivability and growth in cleft grafting of Pummelo are scanty.

Considering the above facts, an attempt was undertaken to investigate the grafting success, survivability and growth of pummelo with the following objectives: i) to observe whether there is any variation in grafting success and survivability in respect of scion wood maturity; ii) to find out the percentages of graft success and survivability during 28 March to 12 August, 2013 in pummelo; and iii) to ascertain the combined effect of scion wood maturity and time of grafting on the success, survivability and subsequent growth of grafts in pummelo.

## Materials and Methods

The present experiment was conducted at the 'BAU Germplasm Centre' (GPC) of Fruit Tree Improvement Program (FTIP), Bangladesh Agricultural University, Mymensingh during the period from March, 2013 to August, 2013. The experiment consisted of two factors with 30 treatment combinations which were as **Factor A - Scion maturity:** M<sub>1</sub> = Terminal/apical portion used as scion, M<sub>2</sub> = Mid portion i.e. just below apical portion used as scion and M<sub>3</sub> = Basal portion i.e. just below mid portion used as scion. **Factor B - Time of grafting:** T<sub>1</sub> = 28, T<sub>2</sub> = 12 April, T<sub>3</sub> = 28 April, T<sub>4</sub> = 12 May, T<sub>5</sub> = 28 May, T<sub>6</sub> = 12 June, T<sub>7</sub> = 28 June, T<sub>8</sub> = 22 July, T<sub>9</sub> = 28 July and T<sub>10</sub> = 12 August.

The two-factor experiment consisting of 30 treatment combinations was laid out in Randomized Complete Block Design (RCBD) with three replications. For each treatment combination grafting operations were performed on twenty rootstocks of each plot of a block.

Thus in total grafts  $3 \times 10 \times 20 \times 3 = 1800$  grafts were made. The treatment combinations were randomly assigned to each unit plot, so as to allot one treatment combination only in each block. Data were analyzed and means were compared by LSD test (Gomez and Gomez, 1993).

## Results and Discussion

### Effects of scion wood maturity and time of grafting on the days required for bud breaking

**Main effect of scion wood maturity:** Scion wood maturity had significant effect on the days required for bud breaking of grafts. Terminal portion used as scion required the minimum time (23.59 days) for bud breaking but basal portion used as scion took (24.08 days) maximum time (Table 1). Terminal portion of shoot was most vigorous and in juvenile condition which required the lowest time for bud breaking.

**Table 1.** Main effect of scion wood maturity on the days required for bud breaking.

Scion wood Maturity	Days required for bud breaking
Terminal portion	23.59
Mid portion	23.94
Basal portion	24.08
LSD at 1%	0.049
Level of significance	**

\*\* = Significant at 1% level of probability

**Main effect of time of grafting:** Days required for bud breaking in ten respective times of grafting was significant. The results on the days required for bud breaking as influenced by the time of operation have been presented in Table 2. The minimum time required for bud breaking (23.04 days) was found in the plants which were grafted on 12 May, while it was maximum (24.77 days) when grafting was done on 28 March. This might be due to favorable environmental conditions which accelerate early bud break.

**Table 2.** Main effect of time of grafting on the days required for bud breaking.

Time of grafting	Days required for bud breaking
28 March	24.77
12 April	24.58
28 April	24.09
12 May	23.04
28 May	23.26
12 June	23.40
28 June	23.57
12 July	23.76
28 July	23.95
12 August	24.28
LSD at 1%	0.089
Level of significance	**

**Combined effect of scion wood maturity and time of grafting on the days required for bud breaking:** The interaction and combined effects of scion maturity and time of grafting operation significantly influenced on the days required for bud breaking of grafts. The maximum time (25.06 days) required for bud breaking was found when basal portion was used as scion and grafted on 28 March, whereas the minimum time (22.91 days) was required in terminal portion used as scion and grafted on 12 May. (Table 3).

### Effects of scion wood maturity and time of grafting on the graft height at different days after grafting

**Main effect of scion wood maturity:** The graft height was significantly influenced by different levels of scion maturity. The variations in graft height have been

presented in Table 4. At 90 DAG, the highest (28.26 cm) and the lowest (25.30 cm) graft height were recorded when terminal and basal portions were used as scion respectively. This is might be due to the variations in the level of graft union, time required for bud breaking and favorable physiological condition of scion.

**Table 3.** Combined effects of scion maturity and time of grafting on the days required for bud breaking

Scion wood maturity	Time of grafting	Days required for bud breaking
Terminal portion	28 March	24.37
	12 April	24.15
	28 April	23.80
	12 May	22.91
	28 May	23.00
	12 June	23.16
	28 June	23.30
	12 July	23.51
	28 July	23.67
	12 August	24.00
Mid portion	28 March	24.89
	12 April	24.67
	28 April	24.13
	12 May	23.07
	28 May	23.33
	12 June	23.46
	28 June	23.67
	12 July	23.80
	28 July	24.02
	12 August	24.35
Basal portion	28 March	25.06
	12 April	24.91
	28 April	24.33
	12 May	23.15
	28 May	23.45
	12 June	23.57
	28 June	23.73
	12 July	23.96
	28 July	24.17
	12 August	24.49
LSD at 1%		0.154
Level of significance		**

**Table 4.** Main effect of scion wood maturity on the graft height at different days after grafting

Scion wood maturity	Graft height (cm) at DAG		
	30	60	90
Terminal portion	23.99	26.15	28.26
Mid portion	23.65	25.80	27.87
Basal portion	23.31	25.40	27.49
LSD at 1%	0.061	0.065	0.069
Level of significance	**	**	**

DAG= Days after grafting

**Main effect of time of grafting:** Data on the increased graft height showed significant variation due to the different time of grafting operation at every date of data recording. Grafting operation performed on 12 May, gave the highest graft height (29.13 cm) at 90 DAG, whereas the lowest graft height (26.43 cm) was found when grafting operation was done on 28 March, (Table 5). This might be due to prevailing congenial climatic condition along with availability of dormant and swollen terminal buds of scion in bulging condition which encouraged earlier sprouting and their continual growth.

### Combined effect of scion wood maturity and time of grafting on the graft height at different days after grafting

The Interaction effects of scion maturity and time of grafting on the graft height was significant. Considering combined effect of scion maturity and time of grafting the variations were found significant at all dates of data collection. At 90 DAG, the highest graft height (29.68 cm) was recorded in the terminal portion used as scion and when grafting operation was done on 12 May, the lowest graft height (26.15 cm) was recorded with the basal

portion when grafting was done on 28 March, at same DAG (Table 6).

**Table 5.** Main effect of time of grafting on the graft height at different days after grafting operation

Time of grafting	Graft height (cm) at DAG		
	30	60	90
28 March	22.38	24.41	26.43
12 April	22.66	24.69	26.70
28 April	23.36	25.43	27.48
12 May	24.73	26.98	29.13
28 May	24.46	26.71	28.86
12 June	24.27	26.52	28.68
28 June	24.07	26.23	28.33
12 July	23.87	26.01	28.11
28 July	23.61	25.75	27.85
12 August	23.06	25.11	27.16
LSD at 1%	0.113	0.119	0.126
Level of significance	**	**	**

**Table 6.** Combined effect of scion wood maturity and time of grafting on the graft height at different days after grafting

Scion wood maturity	Time of grafting	Graft height (cm) at DAG			
		30	60	90	
Terminal portion	28 March	22.60	24.64	26.67	
	12 April	22.89	24.96	26.99	
	28 April	23.63	25.74	27.80	
	12 May	25.19	27.49	29.68	
	28 May	24.88	27.18	29.37	
	12 June	24.63	26.93	29.12	
	28 June	24.49	26.65	28.75	
	12 July	24.28	26.44	28.54	
	28 July	23.93	26.09	28.19	
	12 August	23.35	25.42	27.48	
	Midportion	28 March	22.40	24.46	26.46
		12 April	22.68	24.74	26.74
28 April		23.44	25.51	27.55	
12 May		24.64	26.90	29.03	
28 May		24.42	26.68	28.81	
12 June		24.30	26.56	28.69	
28 June		24.04	26.24	28.32	
12 July		23.82	25.98	28.06	
28 July		23.61	25.75	27.83	
12 August		23.10	25.17	27.21	
Basal portion		28 March	22.15	24.14	26.15
		12 April	22.42	24.37	26.38
	28 April	23.00	25.04	27.09	
	12 May	24.36	26.55	28.69	
	28 May	24.07	26.26	28.40	
	12 June	23.89	26.08	28.22	
	28 June	23.69	25.81	27.92	
	12 July	23.50	25.62	27.73	
	28 July	23.30	25.42	27.53	
	12 August	22.72	24.74	26.79	
	LSD at 1%	0.195	0.206	0.218	
	Level of significance	**	**	**	

### Effects of scion wood maturity and time of grafting on the number of leaves per graft at different days after grafting

**Main effect of scion wood maturity:** The number of leaves per graft was influenced significantly at every date of data collection due to the effect of scion maturity. At 90 DAG, the highest (15.56) and the lowest (13.97) number of leaves per graft were recorded in case of terminal and basal portions used as scion respectively (Table 7). This may be due to early bud breaking and leaf opening.

**Main effect of time of grafting:** The number of leaves per graft was found to be varied significantly at every date of data recording. Grafting operation performed on 12 May 2013, gave the maximum number of leaves (17.25) per graft at 90 DAG, whereas the minimum number of new leaves (11.76) per graft was found when grafting operation was done on 28 March, 2013 at same DAG (Table 8). It may be due to favorable ambience which accelerated early bud breaking and thus secondarily influence on maximum leaf flushing as well as maximum number of leaves.

**Combined effect of scion wood maturity and time of grafting on the number of leaves per graft at different days after grafting:** The average number of leaves

production varied significantly due to the interaction and combined effects of scion maturity and time of grafting at 90 DAG. The results of the collected data on leaf number have been presented in Table 9.

**Table 7.** Main effect of scion wood maturity on the number of leaves per graft at different days after grafting

Scion wood maturity	Number of leaves per graft at DAG		
	30	60	90
Terminal portion	14.05	14.77	15.56
Mid portion	12.59	13.48	14.79
Basal portion	11.53	12.14	13.97
LSD at 1%	0.170	0.205	0.233
Level of significance	**	**	**

**Table 8.** Main effect of time of grafting on the number of leaves per graft at different days after grafting

Time of grafting	Number of leaves per graft DAG		
	30	60	90
28 March	10.29	10.93	11.76
12 April	10.70	11.61	12.49
28 April	12.03	12.81	13.99
12 May	15.22	15.72	17.25
28 May	14.57	15.46	16.92
12 June	14.11	14.85	16.50
28 June	13.40	14.20	15.71
12 July	12.93	13.88	15.14
28 July	12.49	13.08	14.69
12 August	11.47	12.10	13.30
LSD at 1%	0.311	0.375	0.427
Level of significance	**	**	**

**Table 9.** Combined effect of scion wood maturity and time of grafting on the number of leaves per graft at different days after grafting

Scion wood maturity	Time of grafting	Number of leaves per graft at DAG			
		30	60	90	
Terminal portion	28 March	11.05	11.35	11.98	
	12 April	11.29	12.46	12.87	
	28 April	13.40	14.36	14.59	
	12 May	16.67	17.11	18.25	
	28 May	16.15	16.89	17.92	
	12 June	15.95	16.50	17.69	
	28 June	15.33	15.89	16.75	
	12 July	14.59	15.50	16.12	
	28 July	13.88	14.47	15.68	
	12 August	12.14	13.14	13.79	
	Mid portion	28 March	10.50	11.05	11.80
		12 April	10.67	11.75	12.60
28 April		11.80	12.69	13.91	
12 May		15.10	15.95	17.25	
28 May		14.14	15.51	16.95	
12 June		13.69	14.65	16.46	
28 June		13.12	14.20	15.70	
12 July		12.82	13.57	15.14	
28 July		12.45	13.10	14.69	
12 August		11.58	12.30	13.44	
Basal portion		28 March	9.33	10.40	11.50
		12 April	10.14	10.61	12.00
	28 April	10.89	11.37	13.46	
	12 May	13.90	14.10	16.25	
	28 May	13.41	13.98	15.89	
	12 June	12.68	13.40	15.36	
	28 June	11.75	12.50	14.68	
	12 July	11.39	12.56	14.15	
	28 July	11.15	11.66	13.71	
	12 August	10.68	10.86	12.67	
	LSD at 1%	0.537	0.649	0.738	
	Level of significance	**	**	**	

The highest number of leaves (18.25) per graft was recorded in case of terminal portion used as scion and when grafting operation was done on 12 May, while the lowest number of leaves (11.50) per graft was observed in case of basal portion used as scion and when grafting operation was done on 28 March.

### Effects of scion wood maturity and time of grafting on the percentage of graft success

**Main effect of scion wood maturity:** Age of scion had significant effect on the success of grafts at all DAG both at 1% and 5% levels of probability. Terminal portion used as scion gave the highest success (82.54 %) but scion taken from basal portion gave the lowest (81.39%) success (Table 10). This is probably due to more available form of food materials reserved in young terminal portion of scion.

Terminal portion of shoots was most vigorous and in juvenile condition, which helped on the highest graft success.

**Table 10.** Effect of scion wood maturity on the percentage of graft success and survivability

Scion wood maturity	Percentage of graft successes	Percentage of graft survivability
Terminal portion	82.54	
Mid portion	82.15	80.10
Basal portion	81.39	79.48
LSD at 1%	0.203	0.208
Level of significance	**	**

**Table 11.** Effect of time of grafting on the percentage of graft success and survivability

Time of grafting	Percentage of graft successes	Percentage of graft survivability
28 March	75.62	73.89
12 April	77.31	76.72
28 April	80.49	78.14
12 May	88.46	86.62
28 May	86.70	84.52
12 June	85.37	83.32
28 June	84.06	82.44
12 July	82.35	80.45
28 July	81.47	79.47
12 August	78.41	77.43
LSD at 1%	0.371	0.382
Level of significance	**	**

**Table 12.** Combined effect of scion wood maturity and time of grafting on percentage of graft success and survivability

Scion wood Maturity	Time of grafting	Percent of successes	Percent of survivability
Terminal portion	28 March	76.87	75.67
	12 April	77.51	76.90
	28 April	80.90	79.33
	12 May	88.90	87.87
	28 May	87.12	85.44
	12 June	85.70	84.33
	28 June	84.67	83.22
	12 July	82.87	81.67
	28 July	81.93	80.89
	12 August	78.89	77.89
Midportion	28 March	75.39	73.33
	12 April	77.23	76.67
	28 April	80.79	77.77
	12 May	88.71	86.67
	28 May	86.88	84.44
	12 June	85.60	83.33
	28 June	84.33	82.22
	12 July	82.39	80.00
	28 July	81.82	78.89
	12 August	78.33	77.70
Basal portion	28 March	74.60	72.67
	12 April	77.20	76.59
	28 April	79.78	77.33
	12 May	87.77	85.33
	28 May	86.11	83.67
	12 June	84.80	82.29
	28 June	83.19	81.87
	12 July	81.78	79.67
	28 July	80.67	78.63
	12 August	78.00	76.71
LSD at 1%	0.642	0.660	
Level of significance	**	**	

**Main effect of time of grafting on the percentage of graft success:** The percentage of graft success was significantly influenced by the different time of grafting operation. The highest success (88.46%) of grafting was obtained from 12 May and the lowest (75.62%) was from 28 March, which has been presented in Table 11. It was also probably of favorable temperature and relative humidity during grafting. Rapid flow of sap in stock and scion at that time might have contributed in the healing process and established the continuity of cambial and graft take.

**Combined effect of scion wood maturity and time of grafting on the percentage of graft success:** The interaction and combined effects of scion maturity and time of grafting operation significantly influenced on the percentages of graft success. The variations in the

percentage of graft success have been presented in Table 12. Grafting operation done on 12 May with the scion of terminal portion gave the highest percentage of graft success (88.90%) and the lowest (74.60%) was from 28 March with the basal portion used as scion.

**Effects of scion wood maturity and time of grafting on the percentage of graft survivability**

**Main effect of scion wood maturity:** The percentage of graft survivability was significantly influenced by different levels of scion maturity. The effects of scion maturity on the percentage of graft survivability have been presented in Table 10. Among three types scion maturity, the highest (81.32 %) and the lowest (79.48 %) graft survival were observed when terminal portion and basal portion were used as scion respectively. This may be due to having optimum nutrient and hormonal status of terminal portion of scion.

**Main effect of time of grafting:** The final survival of grafts responded significantly due to differences in the time of grafting operation. The maximum percentage of graft survival (86.62%) was found when grafting operation was conducted on 11May, 2013, while the grafting done on 28 March, 2013 gave the minimum (73.89%) survival rate (Table 14). The optimum temperature and atmospheric humidity during 11May grafting might be the main reason which helped in rapid establishment of vascular connection.

**Combined effect of scion wood maturity and time of grafting on the percentage of graft survivability:** The interaction and combined effects of scion maturity and time of grafting on the percentage of graft survival were significantly varied at all DAG. The highest survival rate (87.87%) was found in case of terminal portion used as scion and when grafting operation was done on 12 May, while the lowest survival rate (75.67%) was found from basal portion used as scion and when grafting was done on 28 March. (Table 12). The result of the survivability envisaged that graft survivability was influenced by the cumulative effect of the factors employed in the experiment very much.

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