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Performance of epicotyl grafting in different varieties of mango

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Abstract: The present experiment was conducted at the BAU Germplasm Centre (GPC) of Fruit Tree Improvement Project (FTIP), Bangladesh Agricultural University, Mymensingh during the period from August 2008 to January 2009 to investigate the performance of epicotyl grafting in different varieties of mango. The experiment consisted of (i) BAU released eleven varieties viz., BAU Aam-1, BAU Aam-2, BAU Aam-3, BAU Aam-4, BAU Aam-5, BAU Aam-6, BAU Aam-7, BAU Aam-8, BAU Aam-9, BAU Aam-10 and BAU Aam-11 and ii) three time of grafting operation viz. 6, 16 and 26 August. BAU Aam-6 took minimum time for first emergence, first flush and first leaf opening (9.67, 12.27 and 14.67 days respectively) and showed higher success and survivability (96.67% and 93.33% respectively). The maximum graft height, scion length, rootstock diameter, scion diameter, highest breadth of longest leaf, number of leaves per graft and canopy volume were recorded at BAU Aam-6 (52.69, 18.79, 18.05, 0.67, 0.61, 4.32 cm, 12.68 leaves and 0.0394 m^3, respectively at 150 DAG). In respect of time of grafting operation, 6 August grafting gave the maximum success and survivability (84.54% and 78.18% respectively), minimum time required for first emergence, first flush and first leaf opening (10.12, 12.84 and 15.18 days respectively), maximum graft height, rootstock length, scion length, rootstock diameter, scion diameter, length and breadth of longest leaf, number of new leaves per graft and canopy volume (54.58, 17.65, 15.17, 0.64, 0.54, 20.05, and 4.01 cm, 10.40 leaves and 0.0338 m^3, respectively at 150 DAG). The combined effects of varieties and time of grafting operation were statistically significant on all aforesaid parameters. The minimum time required for first emergence, first flush and first leaf opening (9.00, 11.00 and 14.00 days), higher percentage of success and survivability (both are 96.67%) were achieved in BAU Aam-6 in 6 August grafting. Maximum graft height, scion length, rootstock and scion diameter were achieved at 150 DAG in BAU Aam-6 (62.59, 20.23, 0.68 and 0.64 cm respectively) with 6 August grafting. The highest numbers of new leaves per graft and canopy volume were recorded at 150 DAG in BAU Aam-6 (13.60 leaves and 0.0543 m^3 respectively) when grafting was done at 6 August. Therefore, the results suggest that grafting operation at 6 August with BAU Aam-6 is suitable for higher percentage of success, survivability and growth in mango.
Key words: Epicotyl grafting, varieties, time of grafting, mango.

Introduction

Mango (*Mangifera indica* L.) belonging to the family Anacardiaceae is one of the most important and popular fruits of Bangladesh. It has been cultivated this sub-continent from 4000 years ago (Candole, 1984). It can be propagated by both sexual and asexual (vegetative) methods but the vegetative method is desirable because it enables to retain the characteristics of the mother plant, to get flower and fruit earlier, to remain initially relatively smaller with the benefit of more plants accommodation per unit area and to give the owner's earlier and much higher economic returns. Epicotyl grafting in mango was standardized at the Horticulture Research Station, Krishnanagar by Bhan *et al.* (1969) and they claimed 75 to 80 % success by using germinating seed as a rootstock and semi-mature terminal shoot as a scion. Epicotyl grafting has been successfully using as an efficient, economic and rapid method for the propagation of mango (Bhan *et al.*, 1969; Amin, 1978). It is a general practice that one year old seedlings as rootstocks are used for grafting. But in epicotyl grafting there is no need to wait for one year for the development of rootstocks. Few week old very young seedlings can be used as rootstock for epicotyl grafting. The advantages of this technique of grafting are that the germinating seedlings are in juvenile condition and the cells have the potentiality of quick differentiation and thus play a vital role in the success of graft union. The varieties and grafting methods in case of epicotyl grafting have been found to be important factors for the higher percentage of success, survivability and growth (Jose and Velsalkumari, 1991). Time of grafting operation has a great influence on the success of grafting in mango (Ahmad, 1974). BAU already released eleven varieties of mango but information regarding the influence of time of grafting on the success of these varieties of mango is inconclusive. Considering the above facts the present piece of research work was undertaken to study the effect of varieties and time of epicotyl grafting on success and survivability in mango.

Materials and Methods

The experiment was conducted in the Litchi-Pineapple The experiment was carried out to study the effect of varieties and time of epicotyl grafting on the success and survivability of mango at the 'Germplasm Centre' (GPC) of Fruit Tree Improvement Project (FTIP), Bangladesh Agricultural University, Mymensingh during the period from August 2008 to January 2009. The experiment consisted of two factors: (A) Varieties and (B) Time of grafting. There were eleven varieties of mango released by BAU and three time of grafting treatments. Factor (A): i) V_1=Varieties BAU Aam-1 (Sraboni-1); ii) V_2=BAU Aam-2 (Seedless); iii) V_3= BAU Aam-3 (Diabetic); iv) V_4=BAU Aam-4 (Rad); v) V_5=BAU Aam-5 (Sarboni-2); vi) V_6=BAU Aam-6 (Polyembryoni-1); vii) V_7=BAU Aam-7 (Polyembryoni-2); viii) V_8=BAU Aam-8 (Polyembryoni-3); ix) V_9=BAU Aam-9 (Shoukhin-1); x) V_{10}=BAU Aam-10 (Shoukhin-2) and xi) V_{11}=BAU Aam-11 (Kanchamitha-1). Factor (B): Time of grafting i) T_1=6 August (1^{st} time grafting); ii) T_2=16 August (2^{nd} time grafting) and iii) T_3=26 August (3^{rd} time grafting). The two factor experiment consisting of 33 treatment combinations was laid out in Randomized Complete Block Design (RCBD) with three replications. For each treatment combination grafting operations were performed on ten rootstocks of each plot of a block. Thus in total 990 grafts (33x3x10) were made. The treatment combinations were randomly assigned to each unit plot, so as to allot one treatment combination only in each block.

Results and Discussion

Effect of varieties and time of grafting on days required to first emergence, first flush, first leaf opening and percentage of graft success

Main effect of varieties: The average time required to first emergence of graft was significantly influenced by

the different varieties of mango (Table 1). The minimum time required for first emergence was recorded in BAU Aam-6 (9.36 days) and the maximum was recorded in BAU Aam-4 (11.4 days) and BAU Aam-10 (11.4 days). The minimum time required for first flush was recorded in BAU Aam-6 (12.27 days) while the maximum was recorded in BAU Aam-10 (14.53 days). The minimum time required for first leaf opening was recorded in BAU Aam-6 (14.67 days) and the maximum was recorded in BAU Aam-10 (17.44 days). The higher success was recorded in both BAU Aam-6 and BAU Aam-7 (96.67%). On the other hand, the lowest success was recorded in BAU Aam-10 (73.33%). The significant variation in percentage of graft success might be due to genetical factors of the respective variety.

Table 1. Effect of varieties on days required to first emergence, first flush, first leaf opening and percentage of graft success

Varieties	Days reqd. to first emergence	Days reqd. to first flush	Days reqd. to first leaf opening	Percentage of graft success
BAU Aam-1 (V_1)	10.58	13.69	15.78	75.56
BAU Aam-2 (V_2)	10.49	13.2	15.2	77.78
BAU Aam-3 (V_3)	10.07	13.33	16.53	84.44
BAU Aam-4 (V_4)	11.4	14.24	16.53	82.22
BAU Aam-5 (V_5)	10.93	14.33	16.0	83.33
BAU Aam-6 (V_6)	9.36	12.27	14.67	96.67
BAU Aam-7 (V_7)	10.33	13.13	17.0	96.67
BAU Aam-8 (V_8)	9.67	12.96	16.0	86.67
BAU Aam-9 (V_9)	10.33	13.33	16.4	86.67
BAU Aam-10 (V_{10})	11.4	14.53	17.44	73.33
BAU Aam-11 (V_{11})	10.24	12.47	15.33	76.67
LSD (0.01)	0.47	0.44	0.70	5.73

Main effect of time of grafting: The maximum time required to first emergence (11.07 days) was noted in 26 August (T_3) grafted plants while it was minimum (10.12 days) for 6 August (T_2) grafted plants (Table 2). Earlier emergence during the first and second week of August might be due to the favorable temperature and relative humidity prevailing at that time. Mirdah (2002) reported that August grafting took the longest period (19.52 days) to bud breaking under Mymensingh region. Kumar and Mitra (1994) also noted earlier sprouting during June to August grafting and was delayed in September to October. The maximum time required to first flush (13.98 days) was noted in 26 August (T_3) grafted plants while it was minimum (12.84 days) for 6 August (T_1) grafted plants. The maximum time required to first leaf opening (16.94 days) was noted in 26 August (T_3) grafted plants while it was minimum (15.18 days) for 6 August grafted plants. The highest success was obtained at 6 August grafted plants (84.54%) followed by 16 August grafting (83.03%) and it was lowest in 26 August grafted plants (82.33%). The variation in this success was not significant. This non significant variation might be due to the prevalence varied climate did not affect the grafting operation.

Table 2. Effect of time of grafting on days required to first emergence, first flush, first leaf opening and Percentage of graft success

Time	Days reqd. to first emergence	Days reqd. to first flush	Days reqd. to first leaf opening	Percentage of graft success
T_1	10.12	12.84	15.58	84.54
T_2	10.13	13.4	16.11	83.03
T_3	11.07	13.98	16.94	82.23
LSD (0.01)	0.24	0.23	0.37	2.99NS

NS = Not significant, T_1 = 6 August, T_3 = 26 August, T_2 = 16 August

Combined effect of varieties and time of grafting on days required to first emergence, first flush, first leaf opening and percentage of graft success

The grafting conducted in 26 August (T3) with the variety BAU Aam-7 was found to be taken the maximum time (12.80 days) to emergence while BAU Aam-6 with 6 August (T1) grafting took minimum time (9.00 days) to emergence. The grafting conducted in 26 August (T3) with the variety BAU Aam-7 was found to be taken the maximum time (15.20 days) to flush while BAU Aam-6 with 6 August (T1) grafting took minimum time (11 days) to flush. The grafting conducted in 26 August (T3) with the variety BAU Aam-11 was found to be taken the maximum time (18.20 days) to leaf opening while BAU Aam-6, BAU Aam-4 and BAU Aam-11 with 6 August grafting took minimum time (14 days) to leaf opening. The grafting conducted in 6, 16 and 26 August (T1, T2 and T3 respectively) with the each variety of BAU Aam-6 and BAU Aam-7 was recorded with higher percentage of graft success (96.67% of each variety in each time) while BAU Aam-10 with 6, 16 and 26 August (T1, T2 and T3 respectively) grafting and BAU Aam-4 gave lower percentage of graft success (73.33% of each variety in each time) (Table 3).

Table 3. Combined effect of varieties and time of grafting on days required to first emergence, first flush, first leaf opening and percentage of graft success

Treatment combinations		Days reqd. to first emergence	Days reqd. to first flush	Days reqd. to first leaf opening	Percentage of graft success
Varieties	Time				
BAU Aam-1 (V_1)	T_1	10.4	13.47	15.4	73.33
	T_2	10.53	13.8	15.53	76.67
	T_3	10.8	13.8	16.4	76.67
BAU Aam-2 (V_2)	T_1	10.0	13.0	15.0	76.67
	T_2	10.47	13.0	15.2	80.0
	T_3	11.0	13.6	15.4	76.67
BAU Aam-3 (V_3)	T_1	9.8	13.8	16.8	80.0
	T_2	10.0	13.0	16.0	90.0
	T_3	10.4	13.2	16.8	83.33
BAU Aam-4 (V_4)	T_1	10.0	12.2	14.0	86.67
	T_2	10.4	14.0	17.0	86.67
	T_3	10.6	13.2	17.0	73.33
BAU Aam-5 (V_5)	T_1	11.0	14.0	16.0	90.0
	T_2	10.4	14.4	16.0	76.67
	T_3	11.4	14.6	17.6	83.33
BAU Aam-6 (V_6)	T_1	9.0	11.0	14.0	96.67
	T_2	9.8	12.0	14.0	96.67
	T_3	10.2	13.8	16.0	96.67
BAU Aam-7 (V_7)	T_1	11.2	13.2	16.2	96.67
	T_2	10.6	14.33	17.0	96.67
	T_3	12.4	15.2	17.8	96.67
BAU Aam-8 (V_8)	T_1	9.6	12.6	14.6	76.67
	T_2	8.07	12.47	16.0	90.0
	T_3	10.4	13.8	17.4	93.33
BAU Aam-9 (V_9)	T_1	10.0	13.0	15.0	86.67
	T_2	10.4	13.4	17.4	86.67
	T_3	10.6	13.6	16.8	86.67
BAU Aam-10 (V_{10})	T_1	11.0	14.0	16.0	73.33
	T_2	11.0	14.6	18.13	73.33
	T_3	12.2	15.0	18.2	73.33
BAU Aam-11 (V_{11})	T_1	9.33	11.0	14.0	76.67
	T_2	9.6	12.4	15.0	76.67
	T_3	11.8	14	17.0	76.67
LSD (0.01)		0.81	0.76	1.22	9.92

T_1 = 6 August, T_3 = 26 August, T_2 = 16 August

Effect of varieties and time of grafting on graft height (cm), rootstock length (cm), scion length (cm), rootstock diameter (cm) and scion diameter (cm)

Main effect of varieties: The highest graft height was recorded at 150 DAG in BAU Aam-6 (52.69 cm) and the lowest graft height was found in BAU Aam-10 (35.48 cm). At 150 DAG, BAU Aam-7 variety showed the highest rootstock length (18.79 cm) while the lowest was found in BAU Aam- 10 (14.59 cm). The probable cause behind this variation might be genetical factor and juvenility of rootstock. At 150 DAG, BAU Aam-6 showed the highest scion length (18.05 cm) while the lowest was found in BAU Aam-10 (12.81 cm). At 150 days after grafting operation, the highest increase in rootstock diameter (0.67 cm) was found in BAU Aam-6. On the other hand, the lowest increment of rootstock diameter (0.61 cm) was obtained in BAU Aam-10. At 150 days after grafting operation, the highest increase in scion diameter (0.61 cm) was found in BAU Aam-6. On the other hand, the lowest increase of scion diameter (0.45 cm) was obtained in BAU Aam-10 (Table 4).

Main effect of time of grafting: Grafting operation performed in 6 August gave the highest increase in graft height (54.58 cm) at 150 DAG followed by 26 August which gave the lowest increase in graft height (39.47 cm). Grafting operation performed in 6 August gave the highest increase in rootstock length (17.65 cm) at 150 DAG. followed by 26 August which gave the lowest increase in rootstock length (15.22 cm). Grafting operation performed in 6 August gave the highest increase in scion length (15.17 cm) at 150 DAG followed by 26 August which gave the lowest increase in scion length (14.27 cm). At 150 DAG, the highest increment of rootstock diameter (0.64 cm) was found in case of grafting operation conducted in 6 August. On the other hand, grafting operation conducted in 26 August gave the lowest increment of rootstock diameter (0.63 cm). The variation among the rootstock diameter at three times of grafting was not significant. At 150 DAG, the highest increase of scion diameter (0.54 cm) was found in case of grafting operation conducted at 6 August. On the other hand, grafting operation conducted at 26 August gave the lowest increase of scion diameter (0.51 cm) (Table 5).

Table 4. .Main effect of varieties on increased graft height (cm), rootstock length (cm), scion length (cm), rootstock diameter (cm) and scion diameter (cm)

Varieties	Graft height (cm)	Rootstock length (cm)	Scion length (cm)	Rootstock diameter (cm)	Scion diameter (cm)
BAU Aam-1 (V_1)	46.32	16.61	14.82	0.65	0.53
BAU Aam-2 (V_2)	41.89	15.92	14.12	0.64	0.49
BAU Aam-3 (V_3)	47.39	17.27	14.68	0.62	0.55
BAU Aam-4 (V_4)	38.37	15.48	13.20	0.61	0.47
BAU Aam-5 (V_5)	46.55	17.10	14.71	0.63	0.52
BAU Aam-6 (V_6)	52.69	18.06	18.05	0.67	0.61
BAU Aam-7 (V_7)	50.63	18.79	17.09	0.66	0.60
BAU Aam-8 (V_8)	49.92	18.02	15.49	0.65	0.58
BAU Aam-9 (V_9)	45.87	16.55	14.44	0.63	0.51
BAU Aam-10 (V_{10})	35.48	14.59	12.81	0.61	0.45
BAU Aam-11 (V_{11})	40.57	16.20	13.10	0.62	0.46
LSD (0.01)	3.03	1.44	0.92	0.04	0.03

Table 5. Main effect of time of grafting on graft height (cm), rootstock length(cm), scion length(cm), rootstock diameter(cm) and scion diameter(cm)

Time	Graft height (cm)	Rootstock length (cm)	Scion length (cm)	Rootstock diameter (cm)	Scion diameter (cm)
6 August (T_1)	54.58	17.65	15.17	0.64	0.54
16 August (T_2)	41.14	17.64	14.88	0.63	0.52
26 August (T_3)	39.47	15.22	14.27	0.63	0.51
LSD (0.01)	1.58	0.75	0.48	0.02^{NS}	0.02

NS = Not significant, T_1 = 6 August, T_3 = 26 August, T_2 = 16 August

Effect of varieties and time of grafting on number new leaves and Canopy volume (m^3) per graft

Main effect of varieties: The highest number of new leaves (12.68) was noted in case of variety BAU Aam-6 while the lowest number (6.58) was found in variety BAU Aam-10. At 150 DAG, the maximum increase in canopy volume (0.0394 m^3) per graft was found in BAU Aam-6. On the other hand, the minimum increase in canopy volume (0.0106 m^3) per graft in BAU Aam-10. It was observed that BAU Aam-6 had the highest increase rate of graft height and north-south and east-west plant spreading thus the increase rate in canopy volume was the highest. On the contrary, minimum canopy volume was found in BAU Aam-10 as the increase rate of pant height and north-south and east-west plant spreading was minimum (Table 6).

Main effect of time of grafting: The maximum number of leaves (10.40) per graft was recorded in case of 6 August grafting, while the minimum number of leaves (9.02) per graft was at 26 August grafting. The highest canopy volume (0.0338 m^3) was found in 6 August grafted plant. On the contrary, the lowest canopy volume (0.0178 m^3) was found in 26 August grafted plants. This might be due to favorable ambience, which accelerated early emergence and thus secondarily affected on maximum leaf flushing as well as maximum leaf opening of new growth. The highest canopy volume in 6 August grafted plants also might be due to favorable environmental condition during the entire period of data collection that enhanced the rapid growth of the grafts (Table 7).

Combined effect of varieties and time of grafting on number of new leaves and canopy volume per graft

The average number of leaves production varied significantly due to the combined effect of the varieties and time of grafting at every date of data collection (Table 8). However, at 150 DAG the maximum number of new leaves (13.60) per graft was found in BAU Aam-6 when the grafting was done at 6 August. On the other hand, the minimum number of new leaves (5.50) per graft in BAU Aam-10 when grafting was done at 26 August. This combined effect of two factors employed in the experiment also showed a significant variation in production of leaf number of new growth. At 150 DAG, the highest canopy volume was found in BAU Aam-6 (0.0543 m^3) when grafting conducted at 6 August. On the other hand, grafting conducted at 26 August with BAU Aam-10 gave the lowest canopy volume (0.0067 m^3) (Table 8).

Table 6. Main effect of varieties on number of new leaves and canopy volume of per graft

Varieties	No. of new leaves/graft	Canopy volume (m^3)
BAU Aam-1 (V_1)	9.54	0.0259
BAU Aam-2 (V_2)	8.36	0.0179
BAU Aam-3 (V_3)	10.20	0.0275
BAU Aam-4 (V_4)	8.04	0.0142
BAU Aam-5 (V_5)	9.22	0.0236
BAU Aam-6 (V_6)	12.68	0.0394
BAU Aam-7 (V_7)	12.40	0.0340
BAU Aam-8 (V_8)	11.30	0.0304
BAU Aam-9 (V_9)	8.68	0.0220
BAU Aam-10 (V_{10})	6.58	0.0106
BAU Aam-11 (V_{11})	9.18	0.0167
LSD (0.01)	1.01	0.0027

Table 7. Main effect of time of grafting on number of new leaves and Canopy volume (m^3) per graft

Time	No. of new leaves/graft	Canopy volume/graft (m^3)
T_1	10.40	0.0338
T_2	9.52	0.0199
T_3	9.02	0.0178
LSD (0.01)	0.53	0.0013

T_1 = 6 August, T_2 = 16 August, T_3 = 26 August

Effect of varieties and time of grafting on percentage of graft survivability

Main effect of varieties: The effects of varieties on the percentage of graft survivability have been presented in Fig. 1. The higher survivability was recorded in BAU Aam-7 (93.33%). On the other hand, the lowest survivability was recorded in BAU Aam-10 (64.44%). The significant variation in percentage of graft survivability might be due to genetical factors as well as environmental condition.

Table 8. Combined effect of varieties and time of grafting on number of new leaves and Canopy volume (m^3) per graft

Treatment combinations		No. of new leaves/graft	Canopy volume (m^3)
Varieties	Time		
	T_1	11.00	0.0368
BAU Aam-1 (V_1)	T_2	8.87	0.0199
	T_3	8.79	0.0211
	T_1	8.47	0.0276
BAU Aam-2 (V_2)	T_2	8.13	0.0135
	T_3	8.51	0.0126
	T_1	11.20	0.0372
BAU Aam-3 (V_3)	T_2	9.53	0.0226
	T_3	9.87	0.0227
	T_1	8.80	0.0232
BAU Aam-4 (V_4)	T_2	8.53	0.0098
	T_3	6.80	0.0097
	T_1	9.67	0.0319
BAU Aam-5 (V_5)	T_2	9.40	0.0196
	T_3	8.59	0.0194
	T_1	13.60	0.0543
BAU Aam-6 (V_6)	T_2	12.39	0.0353
	T_3	12.07	0.0287
	T_1	12.33	0.0445
BAU Aam-7 (V_7)	T_2	13.06	0.0337
	T_3	11.83	0.0238
	T_1	10.93	0.0422
BAU Aam-8 (V_8)	T_2	12.13	0.0253
	T_3	10.87	0.0237
	T_1	9.27	0.0308
BAU Aam-9 (V_9)	T_2	8.33	0.0175
	T_3	8.43	0.0178
	T_1	8.40	0.0174
BAU Aam-10 (V_{10})	T_2	5.87	0.0077
	T_3	5.50	0.0067
	T_1	12.40	0.0265
BAU Aam-11 (V_{11})	T_2	7.40	0.0136
	T_3	7.73	0.0102
LSD (0.01)		1.75	0.0047

T_1 = 6 August, T_2 = 16 August, T_3 = 26 August

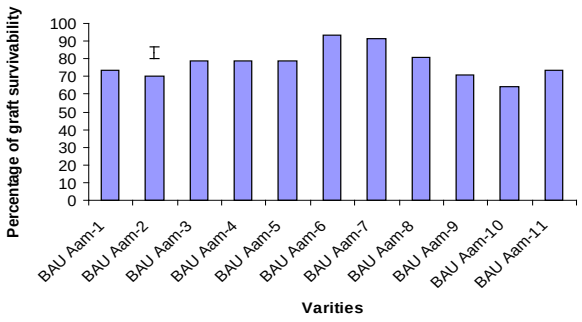

Fig 1. Main effect of varieties on percentage of graft survivability. Vertical bar represents LSD at 0.01 level of significance.

Main effect of time of grafting: The final survival of grafts responded significantly (P<0.01) due to differences in time of grafting (Fig. 2). The maximum percentage of survival was obtained from grafting conducted at 6 August (78.18%), which was followed by the 16 August grafted plants (77.39%) while the grafting done at 26 August gave the lowest (75.45%) survival rate of grafting. The optimum temperature and atmospheric humidity during first and second week of August might be the main reason which increased the grafts compatibility through rapid establishment of vascular connection, thus the highest survival rate was resulted. On the other hand, low temperature and relative humidity during third and fourth week of August and first week of September might have enhanced grafts incompatibility as weak establishment of vascular connection was resulted which finally led to death of successful grafts. These results were in harmony with the previous findings of Dhunaja *et al.* (1988). They reported that survival rates of June and July grafted plants were higher with four months old scion compared to August and was probably due to more success in the beginning in June and July.

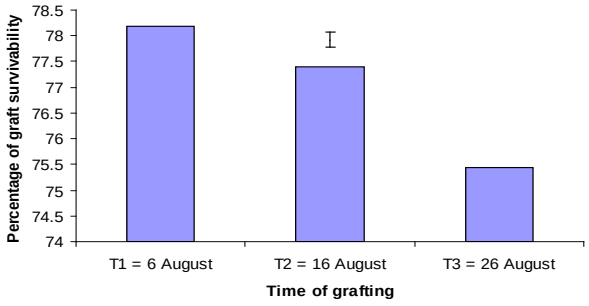

Fig 2. Main effect of time of grafting on percentage of graft survivability. Vertical bar represents LSD at 0.01 level of significance

Combined effect of varieties and time of grafting on percentage of graft survivability

he grafting conducted at 6 August in BAU Aam-6 was found to have the highest survival rate (96.67%). On the contrary, the lowest survival rate (63.33%) was found at 26 August grafted plants (Fig. 3). The results of the survivability envisaged that graft survivability was influenced by the cumulative effect of the factors employed in the experiment very much.

Results of this experiment revealed that varieties and time of grafting significantly influenced on the success, days required to first emergence, first flush and aforesaid parameters. It may be inferred from the present study, that epicotyl grafting operation at 6 August was found suitable for highest success, survivability and plant growth for BAU Aam-6.

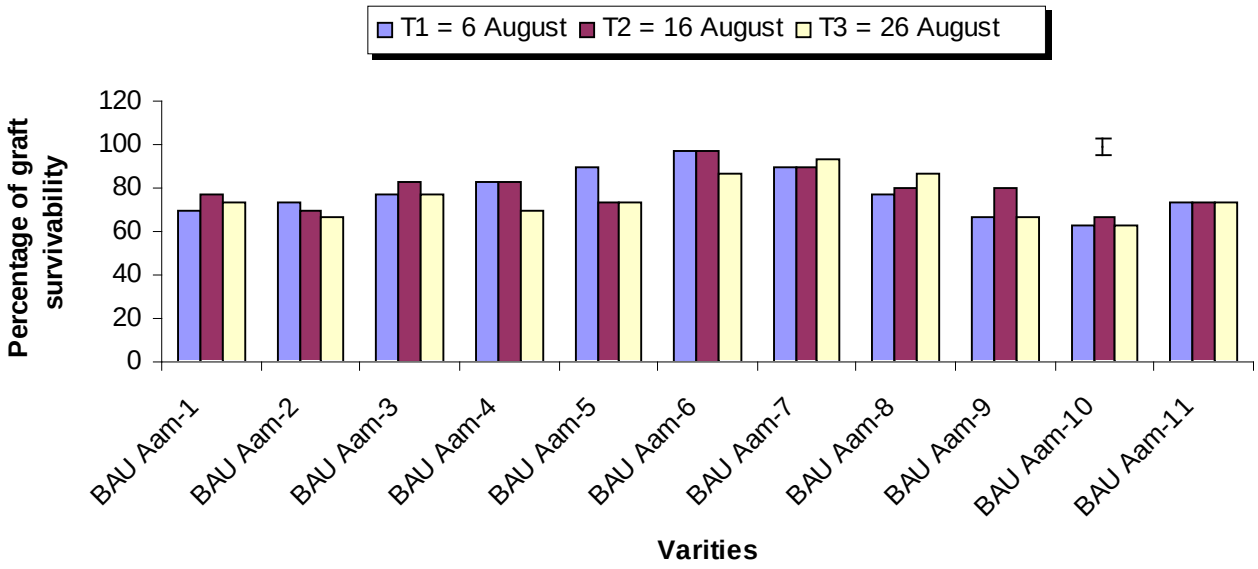

Fig 3. Combined effect of varieties and time of grafting on percentage of graft survivability. Vertical bar represents LSD at 0.01 level of significance.

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