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Standardization of Time and Grafting Techniques in Mango under Bangladesh Condition

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Abstract: Propagation of mango by modified cleft grafting during 15 June showed higher percentage of survival in compare with cleft and veneer grafting irrespective of varieties. The percentage of success was, however, higher in June by modified cleft grafting but in August by veneer grafting. Propagation of plants during June by modified cleft grafting showed highest scion growth with highest number of leaves and shoots.

Key words: Methods of grafting, time, mango

INTRODUCTION

Mango (*Mangifera indica* L.*)* is an important fruit of Bangladesh. It occupies an area of about 50,650 ha[1]. Production of quality mangoes is confined only within the Northwest region of the country. However, mango plants are growing luxuriantly all over Bangladesh. The present production of mango is around 187055 t which comes to about 3.69 t /ha, is very low compared to the production of mango per unit land in India, Thailand, Pakistan and many other mango growing countries of the world[2]. All mangoes grown in different parts of the world can be divided into two groups-monoembryonic and polyembryonic. The former when propagated from seed do not come true to type, whereas the latter breeds true. The most important mango varieties of the world including Bangladesh are monoembryonic, hence there is an urgent need to propagate them vegetatively[3]. There are a few efficient methods of vegetative propagation of mango. A lot of study on the relative efficacy of the different methods of vegetative propagation had been studied in India[4,5] and had been standardized for specific area and region[6,7] but such studies are very scarce under Bangladesh condition. Standardization of grafting techniques is needed for the rapid multiplication of mango for to increase qualitative mango production in Bangladesh. So, this study was undertaken to investigate the relative efficacy of the methods of grafting (veneer, cleft and modified cleft) and to standardize the time of grafting operation in two varieties (cv. Amrapali, a medium dwarf variety and cv. Gopalbhog, tall variety) of mango under Bangladesh condition.

MATERIALS AND METHODS

The experiment was carried out to standardize the time of grafting over different methods in two varieties of mango during April to September 2001. In this experiment, 3 methods of grafting, viz., I) veneer grafting, one of the common methods of vegetative propagation in mango use to practice in the nurseries of different government and non-government organizations of Bangladesh, ii) cleft grafting, one of the worldwide popular methods of vegetative propagation in mango rarely used in Bangladesh and iii) modified cleft grafting, modification of the usual cleft grafting for ease of wrapping, better cambial contact and to save the plants from post grafting mortality (a sketch is attached at the end). The two mango cultivars (cv. Amrapali,' and cv. Gopalbhog) were grafted during April to September (15 April, 15 May, 15 June, 15 July, 15 August and 15 September). The experiment was laid out in 3-factor RCBD with 5 replication considering 10 unit grafts per replication. Thus, 1800 rootstocks 900 for cv. 'Amrapali' and 900 for cv. 'Gopalbhog' were grafted during April to September 2001. The rootstocks for the experiment were planted at the GP center during June-August 2000 at 30x30 cm spacing. The stones for the rootstocks were collected from uniform mother plants, which were monoembryonic and were of unknown varieties. Rootstocks were fertilized and irrigated as per recommendation and was followed by weeding as and when necessary. About one year old rootstock of uniform size and growth were selected for grafting. Disease free 15-20 cm scions shoots having an active dormant terminal bud were collected from selected mother plants. Grafting was done with a sharp grafting knife. Polythene tape was used as wrapping material. The grafts were covered with 20x6 cm white transparent polythene covers. The produced grafts were kept under partial shade for 15-21 days. The grafts were irrigated regularly as and when necessary. The offshoot arisen from the base of the rootstock was removed carefully and timely. The polythene covers were removed timely after bud breaking. The polythene tape was unwrapped

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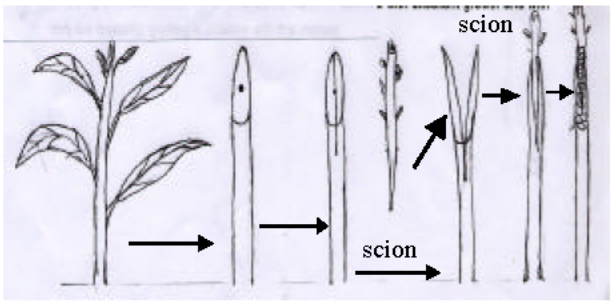
120 days after the grafting operation. The data were recorded on percent survival, growth of rootstock (cm) and scion (cm), number of shoots and leaves/graft.

Modified cleft grafting: Cleft grafting is one of the most acceptable and excellent method of grafting in mango. But still there are some problems exits with this type of grafting while wrapping the graft with polyethylene strip. During heavy rain, rainwater enters into the graft union and ultimately it dies. On the other hand, if the size of the scion and rootstock are of different diameters, it is difficult to match the cambium layer during grafting. As a result, in case of cleft grafting, after high percent of initial success, a considerable amount of graft dies within two-three months after grafting.

To overcome these problems, some modifications were made in the usual cleft grafting, which is named as 'Modified Cleft Grafting'. In this method, a slanting cut of more than 5 cm was made onto the rootstock and a longitudinal cut of 4 cm was made just in the



A sketch of modified cleft grafting

middle of the slanting cut, so that the bark remaining on one side of the rootstock was split into equal halves. Then a 4 cm long wedge cut was made on the scion as in cleft grafting. If the scion is more in diameter than that of the stock, one side of the scion was removed so that it easily matched with the stock. Then the scion was inserted onto the rootstock and tightly wrapped with polyethylene tape. In this case, there was only one option for the propagator to match the cambium layer onto the scion on one side only. The grafts were then covered with 20X6 cm white transparent polythene cover.

RESULTS AND DISCUSSION

Effect of time of operation on survival and growth of the grafts: A highly significant variation was noticed in the survivability of the grafts 120 days after grafting (Table 1). The highest percentage of survivability was found in the plants grafted on 15 June (87.19%) followed by 15 May (82.08%). A continuous decline in the percentage of survivability was recorded when the grafting operation was done before and after June. The lowest percentage of survivability (34.82%) was noticed when the grafting operation was done on 15 September. The results revealed that June is the best time for grafting in mango. The growth of the rootstock varied significantly when measured 120 days after the grafting operation (Table 1). The highest growth of rootstok (4.57 cm) was marked in the plants grafted in April followed by those grafted in June (3.07 cm). The lowest growth of rootstock was found in the plants grafted on 15 September (1.04 cm) followed by those grafted on 15 August (1.52 cm). The result didn't maintain any sequential pattern in the growth of the rootstock. Though the highest growth was noticed in the April operation the second highest was in the June operation. From the July operation and onward, the growth of the rootstock was in a sequential declining pattern. So, the data provided the best growth of the rootstock during the April and June operations. A highly significant variation was noticed in the growth of scion 120 days after the grafting. The highest scion growth (19.34 cm) was found to be attained in the plants grafted in mid June followed by the July (13.87 cm), the May (13.22 cm) and then the April (12.00) operations. The lowest scion growth was noticed during the August (6.65) and September (4.11) operations. A same sequential decline in the growth of scion was marked in pre and post grafting operations of 15 June. The results revealed that 15 June was the best time for mango grafting in respect of scion growth.

The plants grafted in 15 June produced the highest number of shoots (2.86), which is presented in the Table 1. Plants grafted on 15 May were found to produce a mean of number of 2.18 shoots followed by 2.32 in April and 2.07 in the July operation. The plants grafted on 15 August and 15 September produced the lowest mean number of shoots, which differs significantly with the number of shoots produced by the June operation. The result inferred that there was a marked sequential decline in the production of shoots per plant grafted before or after 15 June and the June operation might be the best time for mango grafting in respect of good growth of mango grafts through the production of numerous shoots. Significantly, a higher number of leaves (26.87) were produced in the plants grafted on 15 June followed by the 15 April (24.92) grafting operations. The August and September operations produced the lowest number of leaves (9.69 and 8.22, respectively). The production of leaves by the grafts didn't follow any sequential decline or increase as per the time of grafting. The highest number of leaves was produced in the June operation but the

second highest was in the April operation followed by third highest in the July operation. However, after the July operation a marked decline was noticed in the production of leaves by the grafts. From the investigation, it was revealed that the June operation produced highest number of leaves resulting an excellent growth of the plants.

Varietal performance in grafting: Highly significant variation in the percent of survived grafts was noticed among the cv. 'Amrapali' and 'Gopalbhog' 120 days after grafting (Table 2). The cv. 'Amrapali', grafts survived more (66.13%) than that of the cv. 'Gopalbhog' (63.17%). The result revealed that cv. 'Amrapali' provided good percentage of survival 120 days after grafting. The performance of the Amrapali was better than Gopalbhog in respect of survival of the grafts. This might be due to the varietal characteristics and genetic make of the variety. The rootstock used for both the scion cultivar 'Amrapali' and 'Gopalbhog' showed insignificant differences in growth (Table 2) of rootstock. However, numerically the highest growth was noticed in cv. 'Gopalbhog' (2.52 cm) followed by that of cv. 'Amrapali' (2.50 cm). Growth of the scions 120 days after the grafting operation was influenced significantly by the different varieties of mango as presented in the Table 2. The highest scion growth, 12.31 cm was recorded in cv. 'Gopalbhog' a tall mango variety, whereas 'Amrapali' a dwarf mango variety recorded 10.89 cm growth. The data from the investigation inferred that the tall variety was the best in respect of scion growth. This might be due to the genetic make of the tall variety. The number of shoots produced by grafted plants of two varieties of mango, cv. 'Amrapali' and cv. 'Gopalbhog' differed insignificantly 120 days after the grafting operation. The cv. 'Amrapali' produced a mean number of 1.94 shoots whereas 'Gopalbhog' produced 1.87. So, neither the tall nor the dwarf varieties of mango exerted any effect on growth of the mango graft through production of shoots. The grafts of cv. 'Gopalbhog' produced numerous numbers of leaves, which differed significantly with leaves produced by cv. 'Amrapali' (Table 2). The highest number of leaves (19.60) was found to produce in the grafted plants with 'Gopalbhog' scion but that of 'Amrapali' was (17.95) the lowest. From the result, it was found that the tall variety produced more leaves than that of the dwarf variety of mango and the tall variety might be the best for providing better growth through the production of numerous numbers of leaves.

Effect of time of operation and variety: Plants grafted at different times with the scions of cv. 'Amrapali' and 'Gopalbhog' showed highly significant combined effect among the treatments (Table 3). The highest survival was recorded in cv. 'Amrapali' (89.19%) and 'Gopalbhog' (85.19%) grafted on 15 June. The pre-grafting and post-grafting operations of 15 June showed a gradual decline in percentage of survivability having the lowest on 15 September (35.35% and 34.29% in 'Amrapali' and 'Gopalbhog', respectively). Grafting of cv. 'Amrapali' and 'Gopalbhog' scion onto the in-situ rootstock at different times significantly varied among the treatments (Table 3). The highest growth (4.64 cm) was noticed in cv. 'Gopalbhog followed by cv. 'Amrapali' grafted on 15 April. The 15 June grafted plants were noticed to have the second highest growth in both cultivars of mango grafted in 15 May 15 July, 15 August and 15 September. There was a decline in growth in the plants grafted on 15 May, 15 June, 15 August and 15 September gradually. The lowest rootstock growth was noticed in the plants grafted on 15 September both in cv. 'Amrapali' (1.15 cm) and 'Gopalbhog' (0.93 cm).

The time of grafting operation and different variety significantly affected the growth of scion 120 days after grafting operation (Table 3). The highest growth of scion was noticed in cv. 'Gopalbhog' (19.65 cm) followed by cv. 'Amrapali' (19.04 cm) grafted on 15 April. The second highest growth of scion was attained both in 'Goaplbhog' and 'Amrapali' grafted on 15 June and the lowest was in cv. 'Amrapali' (4.42 cm) followed by 'Gopalbhog' (4.61 cm) grafted on 15 September. From the above results, it was found that the growth of scion didn't follow any sequential pattern with the interaction of the time of grafting and the varieties under investigation. The highest scion growth was noticed in the April grafted plants in cv. 'Gopalbhog' but the second highest scion growth in cv. 'Gopalbhog' was noticed on the June grafted plants. However, clear differences in scion growth of the two varieties were marked throughout the whole grafting period. The highest scion growth was always in the plants grafted with the cv. 'Gopalbhog' scion rather than the cv. 'Amrapali' scion. The results revealed that the better scion growth was in the tall variety producing better growth of the plants.

'Amrapali' and 'Gopalbhog' plants grafted at different times affected the shoot production in mango varieties 120 days after the grafting operation (Table 3). The highest mean number of shoots was found to produce in the 'Amrapali' (2.92) grafted on 15 May followed by 'Gopalbhog' (2.81) and the lowest was in 'Gopalbhog' (0.59) followed by 'Amrapali' (0.60) grafted on 15 September. 'Amrapali' and 'Gopalbhog' grafted at different times affected the production of number of leaves in mango also the highest number of leaves (28.30)

was found to be produced in cv. ''Gopalbhog' followed by those in cv. Amrapali' (25.44) grafted on 15 June. The lowest mean number of leaves (6.86) was found to produce in cv. 'Amrapali' grafted on 15 September. There was a decreasing trend in the production of number of leaves in the plants produced by the pre-grafting and post-grafting operations of 15 June. In most cases, the highest number of leaves was found to produce in the cv. 'Gopalbhog' during the study. The result revealed that the tall variety was the best in growth of the grafts through numerous leaf production.

Effect of methods of grafting: Different methods of grafting, viz. cleft, modified cleft and veneer grafting showed highly significant effect on the survival percentage of the grafts 120 after the grafting operation (Table 4). The highest percentage of survival of grafts was found in the plants grafted by the modified cleft grafting method (68.76%) followed by cleft grafting (64.46%) and the lowest was in veneer grafting (60.73%). From the results, it was found that the efficacy of modified cleft grafting was the best in comparison with the other grafting methods under this investigation. Different methods of grafting showed highly significant variation in the growth of rootstock also (Table 4). The highest growth (2.74 cm) of the rootstock was noticed in the graft produced by modified cleft grafting followed by cleft grafting (2.51 cm) and veneer grating (2.27 cm). From the results, it was inferred that the efficacy of the modified cleft grafting in respect of growth of rootstock was the best.

The growth of the scion was greatly affected by different methods of grafting (Table 4). The highest growth (15.20 cm) of the scion was noticed in the plants produced by modified cleft grafting followed by cleft grafting (11.89 cm) 120 days after the grafting operation. The lowest growth rate of scion was noticed in the plants grafted by veneer grafting. The growth of the grafts was affected mainly by the growth of the scion. Plants produced by different methods of vegetative propagation greatly affects the production of the mean number of new shoots (Table 4). Plants grafted by modified cleft grafting produced a mean number of 2.13 shoots 120 days after the grafting operation, which was the highest number in comparison with other methods of grafting. Plants produced by veneer grafting produced the lowest mean number of shoots (1.60). The number of leaves produced in the grafted plants was affected by different methods of grafting 120 days after the grafting operation (Table 4). The highest mean number of leaves was recorded in the plants produced by modified cleft grafting (21.55) followed by cleft grafting (20.66). The lowest number (14.12) of leaves was found to produce in the plants produced by veneer grafting. The relative efficacy of the modified cleft grafting was the best in respect of survival and growth of grafts in comparison with the other methods of grafting under this investigation, as confirmed by the results.

Effect of time of operation and methods of grafting: The time and methods of grafting affected the percentage of survival of the grafts (Table 5). The highest percentage of grafts (94.09%) was found to survive when the grafting operation was done on 15 June by modified cleft grafting. The second highest percentage of survival was recorded in the grafts produced by modified cleft grafting on 15 May. The percent of surviving grafts produced by cleft grafting at different times of operation closely followed the trend of the modified cleft grafted plants in most cases. An increasing trend was found in the rate of survival of plants produced by veneer grafting. In April, 53.25% was attained but the highest was attained during July operation (63.69%) followed by a declining trend to the lowest (35.33%) during the 15 September operation. However, from the results it was revealed that modified cleft and cleft-grafting methods performed the best during 15 May and 15 June operation and the veneer grafting during the 15 July operation with a higher percentage of surviving grafts. The grafting operation with these three methods of grafting before May and after July didn't appear promising under Bangladesh conditions.

Grafts produced at different times by different methods of propagation affected the growth of rootstock (Table 5). Better growth of rootstock was noticed in early plants grafted by modified cleft grafting. The highest rootstock growth (5.21 cm) was noticed in the plants produced by modified cleft grafting followed by cleft grafting (4.76 cm) grafted on 15 April. The lowest growth of rootstock was noticed in plants raised by veneer grafting on 15 September. In the most cases, the growth of rootstock in the plants produced by veneer grafting grafted from April to September ranked in third position. A highly significant growth of the scion was observed due to the effect of time and methods of grafting 120 days after the grafting operation (Table 5). The highest growth rate of scion (23.46 cm) was observed in the plants grafted on 15 June by modified cleft grafting followed by cleft grafting (21.45 cm). The lowest growth of scion (3.56 cm) was recorded in plants grafted on September by veneer grafting. In the most cases, considerably good growth of scion was observed in the plants produced by modified cleft grafting followed by cleft and veneer grafting. During April, May, June and July a good growth of the scion was noticed with a well-marked decline from the months of

August and September. The results revealed that the modified cleft grafting provided highest survival, rootstock and scion growth if grafted on 15 June which proved the efficacy of the method over other methods of grafting under this investigation referring June as the best time for grafting in mango under Bangladesh conditions.

Grafting of the plants by different methods during April to September affected the production of the mean number of shoots in the grafted plants (Table 5). The highest number of shoots (3.13) was produced in the 15 June grafted plants by modified cleft grafting followed by cleft grafting at the same time. Production of mean number of leaves was significantly affected by the time of operation and methods of grafting also. The plants obtained by modified cleft grafting in April produced the highest number of leaves (30.18) followed by the June (29.78) grafting in modified cleft grafted plants. The lowest mean number of leaves (6.45) was produced in the plants raised by veneer grafting during the September operation. In the case of production of number of leaves, a sequential manner of interaction was observed between the time and the methods of grafting. In the most cases, the highest number of leaves was recorded in the plants produced by modified cleft grafting followed by cleft and veneer grafting. A considerably good number of leaves were produced during the April, June, May and July operations followed by a great decline in the August and September operations. Modified cleft grafting during June proved its efficacy over the other methods of propagation.

Effect of variety and methods: Methods of grafting operation significantly affected the percentage of surviving grafts produced in cv. 'Amrapali' and 'Gopalbhog' 120 days after the grafting operation (Table 6). However, the highest percentage of surviving grafts (71.07%) was recorded in plants produced by modified cleft grafting in cv. 'Amrapali' followed by the cv. Gopalbhog. Growth of rootstock was not affected by different methods of grafting in two mango cultivars, namely cv. 'Amrapali' and 'Gopalbhog' (Table 6). The highest growth of the rootstock was noticed in the plants produced by cleft grafting in the cv. 'Gopalbhog'. Growth of the scion in the plants produced by different grafting methods was affected significantly in cv. 'Amrapali' and 'Gopalbhog' 120 days after the grafting operation (Table 6). The highest scion growth (16.53 cm) was noticed in the cv. 'Gopalbhog' grafted by modified cleft grafting followed by cleft grafting (12.95 cm). The lowest scion growth (7.44 cm) was also noticed in the cv. 'Gopalbhog' raised by veneer grafting. In most of the cases, good scion growth was marked in the plants produced by modified cleft grafting followed by cleft and veneer grafting. The results proved the efficacy of the modified cleft grafting in the cv. 'Gopalbhog' over the other grafting methods providing the highest scion growth of the plants under this study. The combined effect of the mango varieties and methods of grafting did not significantly affect the production of number of shoots 120 days after the grafting operation (Table 6). However, the highest number of shoots was recorded in cv. ' Amrapali' produced by modified cleft grafting. The number of leaves produced in cv. 'Amrapali' and 'Gopalbhog' plants raised by different methods of grafting was noticed to have highly significant effect 120 days after the grafting operation (Table 6). The highest number of leaves was recorded in the cv. 'Gopalbhog' produced by modified cleft grafting.

Effect of time, variety and method of grafting: The time of grafting operation, variety and methods of grafting shown significant differences on the percentage of surviving plants 120 days after the grafting operation (Table 7). The highest percentage of survival (96.07%) was recorded in the modified cleft grafted 'Amrapali' plants grafted during June and that of the lowest (33.82%) was recorded in cleft grafted 'Gopalbhog' plants grafted during September. Modified cleft and cleft grafted 'Amrapali' plants showed excellent performance in percentage of surviving during May and June operation but veneer grafted 'Amrapali' plants showed good performance during July and August operation. The growth of the rootstock was found to be affected by the time of the grafting operation, variety and methods of grafting (Table 7). The highest growth (5.32 cm) of the rootstock was recorded in the modified cleft grafted 'Gopalbhog' plant and that of the lowest (0.69 cm) was recorded in the cleft grafted 'Gopalbhog' plant in September operation. However, the early grafted plants showed higher growth of the rootstock than that of the late grafted plants of the both varieties though cv. 'Amrapali' performed superior to cv. 'Gopalbhog' in most of the cases.

Plants grafted by different methods of vegetative propagation in two varieties of mango at different times showed significant effect on the mean growth of scion (Table 7). The highest growth of scion (24.13 cm) was noticed in cv. 'Gopalbhog' raised by modified cleft grafting on 15 June followed by cleft grafting (23.93 cm). The lowest growth of scion (3.48 cm) was noticed in 'Gopalbhog' grafted on 15 September produced by veneer grafting. Plants produced by different methods of grafting at different times in two varieties of mango significantly affected the production of the mean number of shoots by

Table 1: Effect of time of operation on the survival and growth of grafts 120 days after grafting operation

		Growth (cm) of		Number of	
Time of grafting	% Survival	Rootstock	Scions	Shoots/graft	Leaves/graft
15 April	66.09	4.57	12.00	2.32	24.92
15 May	82.08	2.53	13.22	2.48	19.23
15 June	87.19	3.07	19.34	2.86	26.87
15 July	73.72	2.35	13.87	2.07	23.44
15 August	44.06	1.52	6.65	1.03	9.69
15 September	34.82	1.04	4.11	0.59	8.22
LSD 5%	3.05	0.41	1.44	0.30	2.06
1%	4.03	0.54	1.90	0.39	2.73
Level of Significance	**	**	**	**	**

** = Significant at 1% level

Table 2: Effect of variety on the survival and growth of grafts 120 days after grafting operation

		Growth (cm) of		Number of	
Variety (cv.)	%Survival	Rootstock	Scion	Shoots/plant	Leaves/plant
Amrapali	66.13	2.50	10.89	1.94	17.95
Gopalbhog	63.17	2.52	12.31	1.87	19.60
LSD 5%	1.76	0.23	0.83	0.17	1.19
1%	2.33	0.31	1.09	0.23	1.57
Level of Significance	**	NS	**	NS	**

** = Significant at 1% level, NS= Non-significant

Table 3: Effect of time and cultivar on the survival and growth of grafts 120 days after grafting operation

Treatments			Growth (cm) of		Number of	
Time	Variety	% Survival	Rootstock	Scion	Shoots/graft	Leaves/graft
15 April	Amrapali	68.62	4.50	19.04	2.53	22.90
	Gopalbhog	63.59	4.64	19.65	2.38	26.94
15 May	Amrapali	82.66	2.39	11.56	2.92	18.46
	Gopalbhog	81.48	2.67	12.46	2.81	20.00
15 June	Amrapali	89.19	3.19	12.47	2.26	25.44
	Gopalbhog	85.19	2.94	13.94	2.38	28.30
15 July	Amrapali	75.63	2.21	10.24	2.13	21.49
	Gopalbhog	71.80	2.49	17.50	2.00	25.39
15 Aug.	Amrapali	45.33	1.53	7.45	1.20	9.72
	Gopalbhog	42.68	1.50	5.86	1.00	9.97
15 Sept.	Amrapali	35.50	1.15	4.61	0.60	6.86
	Gopalbhog	34.29	0.93	4.42	0.59	9.58
LSD	5%	4.31	0.41	2.03	0.42	2.92
	1%	5.70	0.51	2.68	0.56	3.86
Level of Significance		**	**	**	**	*

** = Significant at 1% level, * = Significant at 5% level

Table 4: Effect of methods of grafting on the growth of grafts 120 days after grafting operation.

		Growth (cm) of		Number of	
Methods of grafting	% Survival	Rootstock	Scion	Shoots/graft	Leaves/graft
Cleft	64.46	2.51	11.89	1.98	20.66
Modified cleft	68.76	2.74	15.20	2.13	21.55
Veneer	60.73	2.27	7.71	1.60	14.12
LSD 5%	2.16	0.29	1.02	0.21	1.46
1%	2.85	0.38	1.34	0.28	1.93
Level of Significance	**	**	**	**	**

** = Significant at 1% level

the combined effect of the treatments 120 days after the grafting operation (Table 7). The highest number of the shoots/plants (3.18) was found to produce by cleft grafted 'Amrapali' followed by modified cleft grafted 'Amrapali during May operation. The lowest number of shoots/plant (0.28) was recorded in the veneer grafted 'Gopalbhog' plants at September operation. Higher trend of shoot production was marked in the early grafted plants than that of the late grafted plants. The treatment combinations affected the mean number of leaves production in two varieties of mango grafted at different times by different methods of grafting (Table 7). The highest number of leaves/plant (31.93) was found to produce in the modified cleft grafted 'Gopalbhog' plant during June operation but

Table 5: Effect of time and methods on the growth of grafts produced by different methods of grafting, 120 days after grafting operation

Treatments			Growth (cm) of		Number of	
Time	Methods	% Survival	Rootstock	Scion	Shoots/graft	Leaves/graft
15 April	Cleft	66.59	4.76	13.20	2.39	27.00
	Modified Cleft	78.45	5.21	18.53	2.58	30.18
	Veneer	53.25	3.72	13.31	2.39	17.50
15 May	Cleft	84.46	2.62	12.15	2.58	20.64
	Modified Cleft	92.89	2.99	16.67	2.50	22.28
	Veneer	68.85	1.99	7.20	2.39	14.68
15 June	Cleft	89.12	3.29	21.45	3.07	28.60
	Modified Cleft	94.09	3.25	23.46	3.13	29.78
	Veneer	78.36	2.67	7.92	2.01	22.16
15 July	Cleft	69.64	2.05	13.18	2.20	24.89
	Modified Cleft	67.82	2.01	19.91	2.31	29.52
	Veneer	63.69	3.00	8.51	1.70	15.92
15 August	Cleft	42.68	1.46	6.98	1.45	11.04
	Modified Cleft	44.41	1.61	7.07	1.32	11.07
	Veneer	44.93	1.48	5.19	0.84	6.97
15 Sept.	Cleft	34.25	0.88	4.39	0.57	8.55
	Modified Cleft	34.89	1.40	5.59	0.91	9.64
	Veneer	35.33	0.85	3.56	0.30	6.45
LSD	5%	5.28	0.70	2.49	0.52	0.70
	1%	6.98	0.93	3.29	0.68	0.93
Level of significance		**	*	**	**	**

** = Significant at 1% level and * = Significant at 5% level

Table 6: Effect of variety and methods of grafting on the percent survival and growth of grafts 120 days after grafting operation

Treatments			Growth (cm) of		Number of	
Variety	Methods	% Survival	Rootstock	Scion	Shoots/graft	Leaves/graft
Amrapali	Cleft	65.21	2.41	10.84	2.03	19.52
	Modified Cleft	71.07	2.69	13.87	2.17	20.57
	Veneer	62.12	2.38	7.98	1.62	13.77
Gopalbhog	Cleft	63.71	2.61	12.95	1.93	21.80
	Modified Cleft	66.45	2.80	16.53	2.09	22.52
	Veneer	59.35	2.15	7.44	1.59	14.48
LSD	5% level	3.05	0.41	1.44	0.30	2.07
	1% level	4.03	0.54	1.90	0.39	2.73
Level of significance		**	NS	**	NS	**

(NS = Not significant, ** = Significant at 1% level)

the lowest (5.23) was recorded in the veneer grafted 'Amrapali' plants in the September operation. It was found that the early grafted plants produced more number of leaves than that of the late grafted plants and the cv.'Gopalbhog' was found to produce higher number of leaves. From the investigation it was found that grafting during June by modified cleft grafting enhance the higher survival and growth of the plants irrespective of any mango cultivar.

The highest percent survival of grafted plants in June operation might be due to the rainy months of June appeared to be more favourable for propagation under experimental conditions. During this period prevailing temperature and relative humidity favoured the graft union process, which increased better survival of the grafted plants. The low survival in pre and post June operations might be due to the high and low temperature, respectively and low humidity that prevailed in the atmosphere. This might have led to faster desiccation of scion and drying up before graft-take resulting in the failure of operation. The results obtained are in agreement with the results of Singh *et al.*[8]. They found that the percentage of success in grafting operations done in mid June and July was the highest. The success obtained in the grafting operations is also in agreement with the results reported by Ahmad[9], Mukherjee and Majumder[10,11] working under West Bengal and Delhi conditions, respectively. Ram and Bist[12] found almost similar results. As already mentioned, maximum success was obtained in mid June in the present study, Patel and Amin[13] working under Gujrat conditions, obtained maximum success in August. Results obtained by Singh and Srivastava[14] are in conformity with those observed by Patel and Amin. These variations may be due to weather conditions prevailing in different locations in different year, which are not as in Bangladesh.

The highest rootstock growth in the April operation might be due to the excellent physiological condition of the in-situ growing rootstock. As the rootstocks were grown in-situ conditions, optimum temperature and

Table 7: Combined effect of time of operation, variety and methods of grafting on the % survival and growth of grafts 120 days after grafting operation

Treatments				Growth (cm) of		Number of	
Time	Variety	Methods	% Survival	Rootstock	Scion	Shoots/graft	Leaves/graft
15 April	Amrapali	Cleft	67.66	4.42	18.75	2.49	30.08
		M. Cleft	84.00	5.12	22.99	2.71	24.42
		Veneer	54.19	3.96	15.37	2.38	14.19
	Gopalbhog	Cleft	65.52	5.12	12.51	2.50	30.26
		M. Cleft	72.90	5.32	21.78	2.43	29.65
		Veneer	52.32	3.49	10.88	2.20	20.92
15 May	Amrapali	Cleft	85.34	2.32	10.04	3.18	19.68
		M. Cleft	94.24	2.69	17.74	3.17	21.96
		Veneer	68.49	2.15	6.89	2.40	13.73
	Gopalbhog	Cleft	83.58	2.91	14.26	3.09	21.60
		M. Cleft	91.54	3.28	15.59	2.97	22.80
		Veneer	69.28	1.83	7.52	2.36	15.62
15 June	Amrapali	Cleft	91.54	3.19	13.89	2.34	27.86
		M. Cleft	96.07	3.39	15.27	2.48	27.63
		Veneer	79.97	3.00	8.26	1.95	25.46
	Gopalbhog	Cleft	86.71	3.39	23.93	2.39	29.47
		M. Cleft	92.11	3.10	24.13	2.68	31.93
		Veneer	76.74	2.34	7.58	2.07	19.21
15 July	Amrapali	Cleft	69.11	2.01	10.29	2.41	22.39
		M. Cleft	70.64	1.84	13.71	2.31	27.67
		Veneer	87.15	2.79	6.71	1.68	14.41
	Gopalbhog	Cleft	70.17	2.08	16.07	1.99	27.39
		M. Cleft	65.01	2.18	26.11	2.30	31.37
		Veneer	80.22	3.21	10.31	1.71	17.42
15 Aug.	Amrapali	Cleft	42.92	1.45	7.64	1.25	10.07
		M. Cleft	45.93	1.72	7.72	1.40	11.14
		Veneer	47.13	1.42	6.98	0.97	7.94
	Gopalbhog	Cleft	42.44	1.47	6.31	1.05	12.00
		M. Cleft	42.88	1.50	6.42	1.24	11.00
		Veneer	42.73	1.54	4.85	0.71	6.00
15 Sept.	Amrapali	Cleft	34.67	1.07	4.41	0.55	7.01
		M. Cleft	35.53	1.39	5.77	0.94	8.35
		Veneer	35.85	1.00	3.64	0.31	5.23
	Gopalbhog	Cleft	33.82	0.69	4.37	0.58	10.09
		M. Cleft	34.24	1.41	5.40	0.89	10.94
		Veneer	34.80	0.70	3.48	0.28	7.70
LSD		5%	7.47	0.99	3.52	0.73	5.06
		1%	9.87	1.31	4.65	0.97	6.68
	Level of significance		**	**	**	**	**

** = Significant at 1% level

adequate irrigation water enhanced good physiological condition for the growth of the rootstock. Slow growth of the plants during August and September might be due to the gradual decrease in temperature and relative humidity and the gradual increase in dryness of the soil, providing slow physiological activity of the in-situ growing rootstocks[15].

The highest scion growth, number of shoots and leaves, noticed in the plants grafted on 15 June, might be due to a rapid graft union process. At this time, the excellent climatic conditions, viz. optimum growth temperature, adequate relative humidity and soil moisture provided excellent growth for the scions. This is in agreement with the findings of Upadhyay and Prasad[16]. They found that highest scion growth was noticed in June grafted plants. The numerous numbers of leaves also provided a `lot of food materials for the excellent growth of the scion. In the late summer (August-September) the very low growth of the scion, with a lower number of shoots and leaves recorded, might be due to low relative humidity and soil moisture and subsequent low night temperature which retarded the cambial activity of the graft union and also inhibited the growth of the scion resulting in less shoots with leaves.

The highest percentage of 'Amrapali' grafts was found to survive 120 days after the grafting operation. The 'Amrapali' mango cultivar is a hybrid and dwarf mango, which genetically gives strong growth that might be a cause in the rapid formation and dissociation of barrier zone, enhanced intermingling of the vascular bundle, ultimately resulting in the highest percentage of survivability[15].

The lack of significant variation in the growth of the rootstock of the grafts produced by 'Amrapali' and 'Gopalbhog' 120 days after the grafting operation might be due to the fact that stocks were grown in in-situ

conditions providing all sorts of management equally to all rootstocks under this investigation. The varieties had a significant effect on the growth of the scion. The highest scion growth in cv. 'Gopalbhog' might be due to its varietal characteristics. As 'Gopalbhog' is a tall variety, its scion would grow faster than that of the dwarf variety 'Amrapali'. The mean number of leaf production was maximum for the variety 'Gopalbhog' and minimum for the 'Amrapali' might be due the varietal characteristics of the cv. Gopalbhog, which is characterized by numerous small leaves near the node of young twig but the leaves in 'Amrapali' are big and well distributed in the young twig in a definite phyllotaxy with regular intervals. This disagreed with the findings of Kumar and Mitra[4] as they worked with only cv. Himsagar.

The highest percent survival of the plants produced by modified cleft grafting might be due to the relative efficacy of the modified cleft grafting method over other methods of grafting. Modified cleft grafting is the modification of the present cleft grafting method. Its long slanting cut onto the rootstocks, the single option for the matching of the cambium layer, the long cambial layer connection, the easiness of the wrapping of the wrapping materials hindering the entrance of the rain water might be the causes of higher success and survival rate of grafts produced by this method through rapid proliferation and intermingling of vascular tissues. This result is in partial agreement with the findings of Iqbal[17], who identified the cleft grafting as most successful method of propagation in mango in a trail at Siggatoka Research Station, Fiji. The highest growth of the rootstock in the plants produced by modified cleft grafting might be due to the quick graft union process that enhanced the translocation of the food materials from leaves to the rootstock through scion which also enhanced excellent growth for the rootstocks. The highest growth of scion and mean number of shoots and leaves in the plants raised by modified cleft grafting might be due to the long cambium contact zone of the rootstock and the scion inducing adequate callus proliferation, quick dissociation of the barrier zone and a rapid intermingling and interlocking of the vascular tissue[15]. Thus enhanced quick translocation of water and minerals to the scion by the root through the rootstock, quickly produced food materials and ultimately excellent growth of the scion, giving rise to the highest mean number of shoots and leaves.

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