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Effect of different time and growing conditions on growth parameters, success and survival of softwood grafting in mulberry (*Morus nigra* L.) cv. local

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Abstract
The experiment was laid out at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during *kharif* 2017 to find out suitable treatment combination for success and survival of softwood grafting in mulberry. The results revealed that among the four different times of grafting and growing conditions, the grafting on 1st week of July (T_2) under poly house with poly cap required minimum days (16.86) for emergence of sprouting of grafts. Grafting on 1st week of July (T_2) recorded maximum number of fully opened leaves (12.50 and 21.43/plant at 60 and 90 DAG, respectively, percentage of survival (68.41 and 67.00 respectively) while, at 30, 60 and 90 DAG, maximum incremental length of scion (12.86, 33.49 and 64.11 cm, respectively), incremental girth of scion (3.99, 7.24 and 7.51 mm, respectively), incremental girth of rootstock (5.73, 6.75 and 8.47 mm, respectively), percentage of sprouted grafts (55.13, 67.13 and 69.38%, respectively) and number of shoots per plant (4.86) at 90 days after grafting.

Keywords: mulberry, grafting time, growing condition and poly cap

Introduction
The Mulberry (*Morus nigra* L.) belongs to the family Moraceace. The centre of its origin is believed to be Asia. It is wild fruit crop and is also known as shahtur, tut, chinni and tutri in India. The generic name of Morus has been derived from Latin word "Mora", which means delay (Janick and Paul, 2006) [5]. Morus genus has about 68 species of trees and shrubs throughout the world. The species which are found in the country are white mulberry, black mulberry, American mulberry and red mulberry. This genus is widely distributed in Asia, Africa, Europe, South and North America. It is also widely found in hilly areas of Himalayas up to 3300 m elevation (Zafar *et al*., 2013) [16]. It is grown on variety of soil and perform well in the tropical, subtropical and temperate climate. In India, more emphasis has been given for its use in silkworm rearing, not on the fruit, as a result the fruits goes waste.

M. nigra called black mulberry is valued for its fruits. The fruit is a sorosis, highly perishable and used for table purpose. Mulberry fruits have been used for its medicinal properties like nourishment of blood, benefits the kidneys and treat weakness, fatigue, anaemia and premature greying of hairs. Mulberry juice is full of anti ageing properties and enriches the blood, protecting liver from damage, calms the nerves, balances internal secretions and enhances immunity (Yadav *et al*., 2015) [16]. Anthocyanins from mulberry fruits can scavenge free radicals, acts as antioxidants, inhibits low-density lipoprotein oxidation and have beneficial effects on blood lipid and atherosclerosis (Duyen *et al*., 2013 and Du *et al*., 2008) [4, 3]. Fruit contains 85.5% moisture, 0.7% protein, 0.4% fat and minerals, 12.2% carbohydrates and 10 mg vitamin C per 100 g edible flesh. Trees are pruned regularly during December- January when they shed their leaves and a well pruned manured tree yields about 20-40 kg fruits every year. Health beverages are also produced on commercial scale in China, Japan and Korea from this fruit (Singhal *et al*., 2010) [13].

Because of its medicinal value and suitability for planting, the demand is increasing day by day. In mulberry, elite planting material can be developed when desirable mother trees are used for vegetative propagation. The widely adopted vegetative methods of propagation are cutting, budding and grafting. It is well known that union of cambium and grafts take place better when external environmental conditions are favourable. During this period the bark peels off easily and it is full of cell sap.

Materials and Methods

Present investigation was conducted at Horticulture Research Farm, Anand Agricultural University, Anand, from June to December during the year 2017. The treatments comprised four levels of different time of grafting *viz.,* T_1- First week of June, T_2- First week of July, T_3- First week of August and T_4- First week of September with four levels of growing conditions *viz.,* C_1- Net house condition with poly cap, C_2- Net house condition without poly cap, C_3- Poly house condition with poly cap and C_4- Poly house condition without poly cap. The experiment was laid out in a Completely Randomized Design (Factorial) with sixteen treatment combinations and repeated thrice. Total 960 healthy mulberry clonal rootstocks were used for this experiment *i.e.,* 20 plants per treatment.

Raising of the root stock

The cuttings obtained from healthy mother plant and raised in polythene bags of 27.5 x 20 cm size of 300 gauge thickness. The bags were filled with a mixture of farm yard manure and soil (2:1 v/v) and *tricoderma* powder was mixed with potting mixture prior to mulberry plant cuttings raised, as preventive measure against termite attack. After two month cutting were ready for use as clonal rootstock.

Selection of scion and collection

Elite mulberry trees grown on Horticulture Research Farm and other farm of Anand Agricultural University, B. A. College of Agriculture, Anand were selected as mother plant. The scions from healthy and high yielding mother plants were used. One season old, pencil thickness, free from pest and diseases were selected for softwood grafting. The scion shoots were collected directly without curing from selected healthy mulberry trees in the morning hours from 8.30 to 9.30 a.m. on the day of grafting.

Method of grafting

For softwood grafting method, three (3) month old rootstock were used and top growth on the rootstock was decapitated with the help of a knife. The girth of rootstock in that region is almost equal to that of the scion. After this a longitudinal cut of 4 to 5 cm length was given on the terminal trimmed rootstock. The top of the rootstock appeared like the letter 'V'. A scion of about the same thickness as that of the rootstock was selected. The length of the scion was about 9-10 cm. The lower end of the scion was cut into gently sloping wedge of about 3 to 4 cm by removing the bark and a little wood from the two opposite sides. The wedge shaped scion thus prepared was inserted into the 'V' shaped slit of the stock and secured firmly with 1.5 cm wide and 35 cm long, 200 gauge white transparent polythene strip. The scions were covered with small transparent polythene stripes to avoid contamination or desiccation of the scions by creating humidity near and above the union region. This polythene stripe also maintains the temperature and helps for graft union. Cover the scion with polycap (15 cm length, 200 gauge) to maintain humidity and to protect the apical bud from drying. The cap should not touch the terminal bud. Soon after grafting, grafted plants were kept in poly house and net house condition.

Five grafts were selected from each treatment *i.e.* fifteen from all three replications for observation. Observations were recorded in respect to days required for emergence of sprouting of grafts, At 60 and 90 days after grafting, number of fully opened leaves on the scion and percentage of survival and number of shoots per plant at 90 days, while at 30, 60 and 90 days after grafting Incremental length of scion (cm), incremental girth of scion (mm), incremental girth of rootstock (mm) and percentage of sprouted grafts.

The recorded data were analyzed statistically using various techniques as described by Panse and Sukhatme (1978) [10]. The treatment means were compared with C.D. at 5 per cent level.

Results and Discussion

Effect of time

The perusal of data showed the significant effect of grafting time on growth attributes and survival percentage (Table 1 & 2). Grafting during first week of July (T_2) recorded minimum days (16.86) for emergence of sprouts on grafts and maximum number of shoots per plant (4.86) at 90 days after grafting, while at 30, 60 and 90 days after grafting maximum incremental length of scion (12.86, 33.49 and 64.11 cm, respectively), incremental girth of scion (3.99, 7.24 and 7.51 mm, respectively), incremental girth of rootstock (5.73, 6.75 and 8.47 mm, respectively), percentage of sprouted grafts (55.13, 67.13 and 69.38, respectively), whereas, at 60 and 90 DAG maximum number of fully opened leaves (12.50 and 21.43/plant, respectively) and percentage of survival (68.41 & 67.00, respectively). This might be due to the congenial weather condition prevailing during the grafting time triggered cell activity in scion. The higher cell activity results in early sprouting and more number of leaves on scion and other growth parameters. Similar results were also obtained by Pampanna and Sulikeri (2000) [8] in Sapota, Chovatia and Singh (2000) [2] in jamun, Patel *et al*. (2010) [11] in mango and Syamal *et al.* (2012) [15] in guava when they done grafting in the month of July.

Effect of growing conditions

The growing condition C_3 (poly house with poly cap) recorded maximum number of fully opened leaves on scion (9.91 and 16.68/plant, respectively), while, at 30, 60 and 90 DAG, same growing condition recorded maximum incremental length of scion (10.98, 28.00 and 48.91 cm, respectively), incremental girth of scion (3.82 6.15 and 6.89 mm), incremental girth of rootstock (5.13, 6.21 and 8.01 mm, respectively), whereas, at 90 DAG growing condition C_3 (poly house with poly cap) recorded maximum number of shoots per plant (3.78) and percentage of survival (63.41 and 61.16, respectively) (Table 1 & 2). This may be due to the presence of controlled condition inside poly house with polycap which create micro climate around graft union helping for better sprouting and the extension of sprouts and girth of scion and optimum temperature which increases the rate of photosynthesis and leads to formation of more food material and development of graft sprout inside poly house and polycap reduce the rate of transpiration These results are in line with Syamal *et al*. (2012) [15] and Beer *et al.* (2009) [1] in guava, Panday and Singh (2009) [9] in mango, Mahore (2014) [7] in jamun and Sulke (2014) [14] in jackfruit.

Interaction effect of grafting time and growing condition

Different grafting time and growing condition had significant effect on growth attributes and survival percentage (Table 3). Treatment combination T_2C_3 recorded maximum number of fully opened leaves on scion (15.33/plant) at 60 DAG. At 30 and 60 DAG treatment combination T_2C_3 recorded maximum incremental girth of rootstock (6.65 and 7.72 mm, respectively) but at 90 DAG, found non-significant whereas,

treatment combination T_2C_3 recorded maximum incremental length of scion (48.91 cm) and number of shoots per plant (4.93) at 90 DAG, same treatment combination T_2C_3 recorded maximum percentage of survival (70.33) at 90 DAG but found non- significant at 60 DAG. This might be due to the grafting carried out during the congenial weather conditions leads to higher cell activity which results in early sprouting and more number of leaves, in turn synthesized more photosynthates which enhance the growth of scion and thereby increase the growth parameter, success and survival percentage. Similar trend was also observed by Kulwal *et al.* (1985) [6] and Singh & Sengupta (1996) [12] in mango as well as Pampanna and Sulikeri (2000) [8] in sapota.

Table 1: Effect of different time of grafting and growing conditions on growth parameter, success and survival of softwood grafting in mulberry

Treatments	Days required for emergence of sprouting of grafts	Incremental length of scion (cm)			Incremental girth of scion (mm)			Incremental girth of rootstock (mm)			Sprouted grafts (%)		
		At 30 DAG	At 60 DAG	At 90 DAG	At 30 DAG	At 60 DAG	At 90 DAG	At 30 DAG	At 60 DAG	At 90 DAG	At 30 DAG	At 60 DAG	At 90 DAG
Time of grafting (T)													
T_1	22.41	8.24	20.24	30.78	3.55	4.69	6.16	4.00	4.90	6.95	42.43	54.43	60.86
T_2	16.86	12.86	33.49	64.11	3.99	7.24	7.51	5.73	6.75	8.47	55.13	67.13	69.38
T_3	19.29	10.58	27.24	40.61	3.77	5.04	6.83	4.89	6.07	8.01	50.90	62.90	66.55
T_4	20.43	9.65	23.51	34.92	3.67	4.88	6.59	4.50	5.46	7.48	46.66	58.65	63.71
S. Em. ±	0.56	0.33	0.70	0.94	0.02	0.03	0.14	0.06	0.08	0.10	0.96	0.92	1.13
C.D. at 5%	1.61	0.95	2.02	2.70	0.06	0.09	0.40	0.17	0.21	0.29	2.77	2.65	3.25
Growing condition (C)													
C_1	19.50	10.42	27.25	44.77	3.76	6.11	6.80	4.80	5.79	7.72	49.30	61.30	65.48
C_2	20.69	9.77	24.28	36.85	3.69	4.90	6.53	4.53	5.54	7.53	47.20	59.18	64.05
C_3	19.11	10.98	28.00	48.91	3.82	6.15	6.89	5.13	6.21	8.01	50.35	62.40	66.20
C_4	19.70	10.17	24.94	39.88	3.72	4.95	6.61	4.66	5.65	7.65	48.28	60.23	64.78
S. Em. ±	0.56	0.33	0.70	0.94	0.02	0.03	0.14	0.06	0.08	0.10	0.96	0.92	1.13
C.D. at 5%	NS	NS	2.02	2.70	0.06	0.09	0.40	0.17	0.21	0.29	2.77	2.65	3.25
C.V%	9.84	11.15	9.29	7.64	2.22	1.99	7.24	4.27	4.49	4.65	6.83	5.25	6.00
(T × C)	NS	.NS	NS	Sig.	NS	Sig.	NS	Sig.	Sig.	NS	NS	NS	NS

Table 2: Effect of different time of grafting and growing conditions on growth parameter, success and survival of softwood grafting in mulberry

Treatments	Numbers of shoots per plant At 90 DAG	Number of fully opened leaves		Percentage of survival	
		At 60 DAG	At 90 DAG	At 60 DAG	At 90 DAG
Time of grafting (T)					
T_1	1.86	7.03	11.63	49.33	46.58
T_2	4.86	12.50	21.43	68.41	67.00
T_3	3.76	8.75	15.56	65.41	62.58
T_4	2.78	7.78	13.46	57.33	55.25
S.Em. ±	0.04	0.27	0.38	0.66	0.63
C.D. at 5%	0.12	0.79	1.08	1.91	1.80
Growing condition (C)					
C_1	3.30	9.60	16.30	60.33	57.75
C_2	2.95	8.03	13.98	57.25	55.50
C_3	3.78	9.91	16.68	63.41	61.16
C_4	3.25	8.51	15.13	59.50	57.00
S.Em. ±	0.04	0.27	0.38	0.66	0.63
C.D. at 5%	0.12	0.79	1.08	1.91	1.80
C.V%	4.52	10.54	8.39	3.83	3.76
(T × C)	Sig.	Sig.	NS	NS	Sig

Table 3: Interaction effect of different grafting time and growing conditions on growth parameters, success and survival of softwood grafting in mulberry

Treatment	Incremental length of scion (cm) at 90 DAG	Incremental girth of scion (mm) at 60 DAG	Incremental girth of rootstock (mm)		Numbers of shoots per plant At 90 DAG	Number of fully opened leaves at 60 DAG	Percentage of survival at 90 DAG
			AT 30 DAG	AT 60 DAG			
T_1C_1	31.34	4.72	4.12	5.03	2.00	7.60	47.66
T_1C_2	28.66	4.65	3.68	4.54	1.46	6.80	43.33
T_1C_3	32.28	4.74	4.17	5.14	2.06	7.40	49.33
T_1C_4	30.73	4.66	4.02	4.89	1.93	6.33	46.00
T_2C_1	70.86	9.76	5.45	6.60	4.93	12.20	67.00
T_2C_2	49.10	5.23	5.40	6.35	4.80	9.93	64.66
T_2C_3	81.53	9.76	6.65	7.72	4.93	15.33	70.33
T_2C_4	54.95	5.31	5.43	6.36	4.80	12.53	66.00
T_3C_1	41.42	5.07	5.00	6.07	3.46	9.46	62.66
T_3C_2	36.56	4.94	4.78	5.94	3.33	8.00	62.33
T_3C_3	45.68	5.18	5.01	6.34	4.80	9.26	63.00
T_3C_4	38.80	4.95	4.79	5.96	3.46	8.26	62.33

T_4C_1	35.46	4.90	4.65	5.48	2.80	9.13	53.66
T_4C_2	33.10	4.78	4.26	5.34	2.20	7.40	51.66
T_4C_3	36.07	4.94	4.70	5.63	3.33	7.66	62.00
T_4C_4	35.06	4.88	4.41	5.40	2.80	6.93	53.66
S. Em. ±	1.88	0.06	0.12	0.15	0.09	0.55	1.26
C.D. at 5%	5.41	0.18	0.34	0.43	0.24	1.58	3.61
C.V%	7.64	1.99	4.27	4.49	4.52	10.54	3.76

Conclusion

In the light of the results obtained it can be concluded that for getting higher success and survival of softwood grafting in mulberry grafting should be done in 1st week of July under poly house condition with the use of poly cap. Beside it also improved growth characters of graft *viz.*, number of fully opened leaves on scion, incremental length and girth of scion, incremental girth of rootstock as well as number of shoots per plant.

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