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KD Mithapara
Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

KM Karetha
Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
KD Mithapara
Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Effect of season and environmental conditions on softwood grafting of sapota under Saurashtra region of Gujarat cv. Kalipatti

KD Mithapara and KM Karetha

Abstract
An investigation on "Effect of season and environmental conditions on softwood grafting of sapota under Saurashtra region of Gujarat cv. Kalipatti" was carried out at Hi-Tech Horticulture Park, Department of Horticulture, JAU, Junagadh during the year 2019-20. The treatments comprised of three level of season (S) viz., S_1 = February-March (Summer), S_2 = June-July (Kharif), S_3 = September-October (Winter) and three level of environmental conditions (C) *viz*., C_1 = Open field, C_2 = Net house, C_3 = Polyhouse. The experiment was laid out in Completely Randomized Design (CRD) with Factorial concept comprising nine treatment combinations with three replications. The result indicated that among season June-July recorded minimum number of days required for emergence of sprout (11.72). February-March recorded highest success rate (56.94%, 59.72%, 59.72% and 59.72%) with minimum mortality (43.06%, 40.28%, 40.28%, and 40.28%), maximum survival percentage (56.94%, 58.00%, 55.56% and 55.56%) at 30, 60, 90 and 120 DAG, respectively. The result indicated that among environmental conditions polyhouse recorded minimum number of days required for emergence of sprout (10.34), highest success rate (40.17%, 44.00%, 44.00% and 44.00%), minimum mortality (59.83%, 56.00%, 56.00% and 56.00%) and maximum survival percentage (40.17%, 43.00%, 43.44% and 43.44%) at 30, 60, 90 and 120 DAG, respectively.

Keywords: Sapota, softwood grafting, season, environmental conditions

Introduction
Sapota is botanically known as *Manilkara achras* (Mill.) Fosberg (Synonym: *Achras zapota* L.), an evergreen tree and important tropical fruit belonging to the family Sapotaceae. It is locally known as 'Chickoo' and 'Sapeta' by peoples of different states of India while internationally known as 'Sapodilla', 'Zapota' and 'Noseberry' (Parle and Preeti, 2015) [27].
Since, inarch grafting or approach grafting have been commercially adapted method of vegetative propagation of sapota in the country for longer time. But this method has some disadvantages like it is cumbersome and laborious because rootstock seedlings have to be carried to the mother plant for grafting, expensive, time-consuming and also fails to produce erect plants with uniform canopy. The problem in approach grafting is takes longer time for the graft success thus; a lot of expenditure and time is spent for maintenance of sapota grafts (Shirol *et al*., 2005) [31].
As a solution to these problems an alternative method to approach grafting; softwood grafting, a detached method of grafting is becoming very popular and has substantially revolutionized fruit industry in terms of quality planting material in our country. Now, softwood grafting is commercially standardized in many fruit crops like mango (Amin, 1974) [1], sapota (Pampanna and Sulikeri, 2000) [23], guava (Singh *et al*., 2007) [32], jamun (Mulla *et al*., 2011) [20], custard apple (Ghosh *et al*., 2004) [11], cashew (Swamy *et al*., 1990) [35], jackfruit (Selvi, 2005) [29], aonla (Panchbhai *et al*., 2006) [24] etc. This method is easy, cheap, involves simple skill, convenient in handling, economically viable, cost effective, easier to adopt, rapid, can give considerable percentage of success and grafts are ready for sale within a year. Normally, grafts raised by this method produce erect and stout plants of uniform canopy, which is one of the most important prerequisites for successful modern orchard like high density planting system. The most important feature of this method is that, it allows higher rate of multiplication of plants and resultant plants will be vigorous. Besides these, it is very much effective in dry, hot weather or in areas of low precipitation especially in arid regions. Also this method becomes important when planting materials from mother plants are limited as many grafts prepared from a single tree.
Propagation period of sapota in Gujarat lasts from February-July. Only 4-5 months are suitable for propagation. Grafting is mostly carried out on the onset of monsoon which limits the

availability of planting material for that particular season. Therefore, using poly and net house to improve the efficiency of propagating period and also useful for production of off-seasonal planting material. A controlled environmental condition showing congenial for faster healing and callus formation results in better success and survival of grafts (Chander, 2016a) [5]. The controlled environment conditions including mist chamber, shade net, low tunnel and green house, where one can increase the rate of success percent by providing favorable conditions (Vishnuvardhan, 2002) [37]. In India, construction of temporarily low cost polyhouse is become popular for raising nursery of fruit plant in off-season.

A lot of research work has been done on propagation of sapota at various places regarding with seasonal variation and influence of climatic conditions on success of grafting. But information regarding to the impact of season and environmental conditions on successful grafting of sapota under Saurashtra region of Gujarat conditions is still unknown. Keeping in view of above facts and lacking research finding of propagation techniques of sapota for Saurashtra region of Gujarat, an attempt was made to find out the suitable season as well as propagation environment for their response to percentage success in comparison with open conditions to obtain commercial production of grafts throughout the year. So, the present investigation entitled "Effect of season and environmental conditions on softwood grafting of sapota under Saurashtra region of Gujarat" was carried out.

Material & Methods

The present investigation was carried out at Hi-Tech Horticulture Park, Department of Horticulture, JAU, Junagadh during the year 2019-20. The treatments comprised of three level of season (S) viz., S_1 = February-March (Summer), S_2 = June-July (Kharif), S_3 = September-October (Winter) and three level of environmental conditions (C) *viz*., C_1 = Open field, C_2 = Net house, C_3 = Polyhouse. The experiment was laid out in Completely Randomized Design (CRD) with Factorial concept comprising nine treatment combinations with three replications. Junagadh is situated in South Saurashtra Agro-climatic region of Gujarat state. Geographically, this place is situated at 21.5º N latitude and 70.5º E longitude with an altitude of 60 meters above the mean sea level and 80 kilometers away from Arabian Sea Coast on western side at the foothill of the mount Girnar.

The grafting operation was done on 1.5 years old khirni rootstock seedlings. Non-flowered terminal or lateral shoots of current season's growth with pencil thickness, greenish brown coloured mature and healthy scions were collected from Kalipatti variety of sapota trees at Hiravadi Farm, Department of Soil and Water Conservation Engineering, College of Agricultural Engineering and Technology, JAU, Junagadh. Defoliation of scion on mother tree was done at 15 days prior to grafting. The petiole stubs dried up and dropped off when touched leaving a healed scar of defoliated scion sticks at this stage indicated that scion was ready for grafting. Unsprouted scion sticks with well-developed buds were detached from the selected mother tree in the morning on the day of grafting.

Method of softwood grafting

On the rootstock two pairs or 3-4 bottom leaves were retained and the other leaves were removed using a sharp grafting knife. The selected rootstock was headed back about 15 cm above the polybag where soft wood portion was available on the rootstock and the terminal shoot was removed with the help of secateur. A deep vertical straight cut of 4 cm was made on the center of the beheaded rootstock with the help of sharp grafting knife. A matching thickness of rootstock, scion was reduced to a convenient length for grafting and cutting off the excess portion at the bottom with the help of secateur to exposes fresh tissue. Slant cut was made in both sides of lower part of scion stick to make a V-wedge shaped smooth cut of same length (4 cm) and to retain some bark on the remaining two sides with thin tip of wedge using a sharp grafting knife. V-wedge shaped scion stick inserted into the splitted rootstock. The graft joint was secured properly with 2 cm wide and 30 cm long white polythene strip of 200 gauge thickness in order to provide proper contact of cambium cells and avoid the desiccation of the graft union.

The observations were recorded on various parameters *viz.*, Days required for emergence of sprout (Days), Success rate (%), Mortality (%) and Survival percentage (%). Except for days required for emergence of sprout, all other parameters were recorded at 30, 60, 90 and 120 DAG. Various characters under study were statistically analysed by using analysis of variance technique for Completely Randomized Design (CRD) with Factorial concept as described by Panse and Sukhatme (1985) [25]. Success rate, mortality and survival percentage were calculated by following formula.

$$\text{Success rate (\%)} = \frac{\text{No. of sprouted grafts}}{\text{Total no. of plants grafted}} \times 100$$

$$\text{Mortality (\%)} = \frac{\text{No. of failed grafts}}{\text{Total no. of plants grafted}} \times 100$$

$$\text{Survival percentage (\%)} = \frac{\text{No. of grafts remained alive}}{\text{Total no. of plants grafted}} \times 100$$

Results & Discussion

Days required for emergence of sprout (Days):

Among season minimum number of days required for emergence of sprout (11.72) was noted in S_2 (June-July) which was at par with S_1 (February-March). Maximum number of days required for emergence of sprout (13.18) was noted in S_3 (September-October). Earlier sprouting might be due to that June-July month coincided with monsoon that was congenial climatic condition such as moderate temperature and high relative humidity triggered cell activity in scion. The similar kind of findings were recorded by Wazarkar *et al*. (2009) [38] in sapota; Sonawane *et al.* (2012) [34] in carambola; Kumar *et al*. (2017) [19] in guava; Bodkhe and Rajput (2010) [4] in jamun.

Among environmental conditions minimum number of days required for emergence of sprout (10.34) was noted in C_3 (Polyhouse). Maximum number of days required for emergence of sprout (14.64) was noted in C_1 (Open field). Earlier sprouting might be due to creation of high humidity and reduced the desiccation of active tissue of scion in polyhouse as compared to other conditions. The similar kind of findings were recorded by Jalal *et al.* (2018) [14] in aonla and Patel *et al.* (2007) [28] in mandarin.

Among interaction effect minimum number of days required for emergence of sprout (8.80) was noted in S_2C_3 (June-July + Polyhouse) which was at par with S_1C_3 (February-March + Polyhouse). Maximum number of days required for emergence of sprout (15.27) was noted in S_2C_1 (June-July + Open field). The similar kind of findings were recorded by Nitish *et al.* (2019) [22] in sapota; Syamal *et al.* (2012) [36] in guava and Parmar *et al.* (2019) [38] in mulberry.

Table 1: Effect of season and environmental conditions on days taken for emergence of sprout (Days) and success rate (%) of sapota cv. Kalipatti

Treatments		Days required for emergence of sprout (Days)	Success rate (%)			
			30 DAG	60 DAG	90 DAG	120 DAG
A. Season						
S_1 (February-March)		12.24	56.94	59.72	59.72	59.72
S_2 (June-July)		11.72	33.44	35.72	36.17	36.17
S_3 (September-October)		13.18	20.44	24.89	25.11	25.11
S.Em.±		0.364	1.346	1.448	1.665	1.665
C.D. at 5%		1.08	4.00	4.30	4.95	4.95
B. Environmental Conditions						
C_1 (Open field)		14.64	35.78	37.22	37.44	37.44
C_2 (Net house)		12.16	34.89	39.11	39.56	39.56
C_3 (Polyhouse)		10.34	40.17	44.00	44.00	44.00
S.Em.±		0.346	1.346	1.448	1.665	1.665
C.D. at 5%		1.08	4.00	4.30	4.95	4.95
Interaction (S x C)						
T_1	S_1C_1	14.77	65.00	65.83	65.83	65.83
T_2	S_1C_2	12.20	53.33	56.67	56.67	56.67
T_3	S_1C_3	9.77	52.50	56.67	56.67	56.67
T_4	S_2C_1	15.27	20.33	21.17	21.17	21.17
T_5	S_2C_2	11.10	24.00	28.67	30.00	30.00
T_6	S_2C_3	8.80	56.00	57.33	57.33	57.33
T_7	S_3C_1	13.90	22.00	24.67	25.33	25.33
T_8	S_3C_2	13.17	27.33	32.00	32.00	32.00
T_9	S_3C_3	12.47	12.00	18.00	18.00	18.00
S.Em.±		0.630	2.331	2.508	2.883	2.883
C.D. at 5%		1.87	6.93	7.45	8.57	8.57
C.V. %		8.81	10.93	10.83	12.38	12.38

Success rate (%)

Among season highest success rate (56.94%, 59.72%, 59.72% and 59.72%) at 30, 60, 90 and 120 DAG, respectively was noted in S_1 (February-March). Lowest success rate (20.44%, 24.89%, 25.11% and 25.11%) at 30, 60, 90 and 120 DAG, respectively was noted in S_3 (September-October). Better success during February-March that the scions collected during this month had received sufficient auxin and carbohydrate accumulated for flowering which promoted the higher graft-take. The similar kind of findings were recorded by Ghosh *et al.* (2004) [11], Kudmulwar *et al.* (2008) [17], Dhutraj *et al.* (2018a) [9], Dhutraj and Baghat (2019) [7] in custard apple; Chouksey, *et al.* (2016) [6] in guava; Dhutraj and Baghat (2019) [7], Ghojage *et al.* (2011) [10] in jamun; Shinde *et al.* (1996) [30], Dhutraj *et al.* (2018b) [8], Dhutraj and Baghat (2019) [7] in tamarind; Singh and Singh (2015) [33] in khirni.

Among environmental conditions highest success rate (40.17%, 44.00%, 44.00% and 44.00%) at 30, 60, 90 and 120 DAG, respectively was noted in C_3 (Polyhouse) which was at par with C_2 (Net house) at 90 and 120 DAG. Lowest success rate (34.89%) at 30 DAG was noted in C_2 (Net house) whereas, (37.22%, 37.44% and 37.44%) at 60, 90 and 120 DAG, respectively was noted in C_1 (Open field). Higher success might be due to congenial conditions inside polyhouse for longer period which prevent desiccation of active tissue of scion. The similar kind of findings were recorded by Nagargoje *et al.* (2016) [21] in sapota; Patel *et al.* (2007) [28] in mandarin; Singh *et al.* (2007) [32] and Joshi *et al.* (2016) in guava.

Among interaction effect highest success rate (65.00%, 65.83%, 65.83% and 65.83%) at 30, 60, 90 and 120 DAG, respectively was noted in S_1C_1 (February-March + Open field) which was at par with S_2C_3 (June-July + Polyhouse) at 90 and 120 DAG. Lowest success rate (12.00%, 18.00%, 18.00% and 18.00%) at 30, 60, 90 and 120 DAG, respectively was noted in S_3C_3 (September-October + Polyhouse). The similar kind of findings was recorded by Kukshal *et al.* (2017) [18] in guava.

Mortality (%)

Among season minimum mortality (43.06%, 40.28%, 40.28%, and 40.28%) at 30, 60, 90 and 120 DAG, respectively was noted in S_1 (February-March). Maximum mortality (79.56%, 75.11%, 74.89% and 74.89%) at 30, 60, 90 and 120 DAG, respectively was noted in S_3 (September-October). This might be attributed that new callus tissue arising out of the cambial region consists of thin walled turgid cells which easily desiccated and die off due to dry weather and higher relative humidity can protect such cells in the cambial region of the graft union (Hartman and Kester, 1979) [13].

Among environmental conditions minimum mortality (59.83%, 56.00%, 56.00% and 56.00%) at 30, 60, 90 and 120 DAG, respectively was noted in C_3 (Polyhouse) which was at par with C_2 (Net house) at 90 and 120 DAG. Maximum mortality (65.11%) at 30 DAG was noted in C_2 (Net house) whereas, (62.78%, 62.56% and 62.56%) at 60, 90 and 120 DAG, respectively was noted in C_1 (Open field). This might be due to that uncongenial conditions results in faster desiccation of scion sticks and drying up before graft-take.

Among interaction effect minimum mortality (35.00%, 34.17%, 34.17% and 34.17%) at 30, 60, 90 and 120 DAG, respectively was noted S_1C_1 (February-March + Open field) which was at par with S_2C_3 (June-July + Polyhouse) at 90 and 120 DAG. Maximum mortality (88.00%, 82.00%, 82.00% and 82.00%) at 30, 60, 90 and 120 DAG, respectively was noted S_3C_3 (September-October + Polyhouse). The similar kind of findings was recorded by Beer *et al.* (2013) [2] in guava.

Survival percentage (%)

Among season maximum survival percentage (56.94%, 58.00%, 55.56% and 55.56%) at 30, 60, 90 and 120 DAG, respectively was noted in S_1 (February-March). Minimum survival percentage (20.44%, 24.00%, 24.00% and 24.00%) at 30, 60, 90 and 120 DAG, respectively was noted in S_3 (September-October). This might be due to that presence of enough carbohydrate and other food material in the scion collected during February-March season and the accumulated food material was mobilized for new growth which in turns high meristematic activity in scion. The similar kind of findings were recorded by Kholia *et al.* (2017) [16] in guava; Ghojage *et al.* (2011) [10] and Bharad and Mahorkar (2011) [3] in jamun.

Among environmental conditions maximum survival percentage (40.17%, 43.00%, 43.44% and 43.44%) at 30, 60, 90 and 120 DAG, respectively was noted in C_3 (Polyhouse). Minimum survival percentage (34.89%) at 30 DAG was noted in C_2 (Net house) whereas, (35.56%, 34.78% and 34.78%) at 60, 90 and 120 DAG, respectively was noted in C_1 (Open field), This might be due to that polyhouse received prevailing fairly long periods of favourable temperature and relative humidity for survival of grafts. The similar kind of findings were recorded by Gotur *et al.* (2017b) [12] and Patel *et al.* (2007) [28] in mandarin.

Among interaction effect maximum survival percentage (65.00%, 64.00%, 61.67% and 61.67%) at 30, 60, 90 and 120 DAG, respectively was noted S_1C_1 (February-March + Open field) which was at par with S_2C_3 (June-July + Polyhouse) at 60 DAG, at par with S_1C_3 (February-March + Polyhouse) and S_2C_3 (June-July + Polyhouse) at 90 and 120 DAG. Minimum survival percentage (12.00%, 18.00%, 18.00% and 18.00%) at 30, 60, 90 and 120 DAG, respectively was noted S_3C_3 (September-October + Polyhouse).

Table 2: Effect of season and environmental conditions on mortality (%) and survival percentage (%) of sapota cv. Kalipatti

Treatments		Mortality (%)				Survival percentage (%)			
		30 DAG	60 DAG	90 DAG	120 DAG	30 DAG	60 DAG	90 DAG	120 DAG
A. Season									
S_1 (February-March)		43.06	40.28	40.28	40.28	56.94	58.00	55.56	55.56
S_2 (June-July)		66.56	64.28	63.83	63.83	33.44	34.44	34.89	34.89
S_3 (September-October)		79.56	75.11	74.89	74.89	20.44	24.00	24.00	24.00
S.Em.±		1.346	1.448	1.665	1.665	1.346	1.694	1.905	1.905
C.D. at 5%		4.00	4.30	4.95	4.95	4.00	5.03	5.66	5.66
B. Environmental Conditions									
C_1 (Open field)		64.22	62.78	62.56	62.56	35.78	35.56	34.78	34.78
C_2 (Net house)		65.11	60.89	60.44	60.44	34.89	37.89	36.22	36.22
C_3 (Polyhouse)		59.83	56.00	56.00	56.00	40.17	43.00	43.44	43.44
S.Em.±		1.346	1.448	1.665	1.665	1.346	1.694	1.905	1.905
C.D. at 5%		4.00	4.30	4.95	4.95	4.00	5.03	5.66	5.66
Interaction (S x C)									
T_1	S_1C_1	35.00	34.17	34.17	34.17	65.00	64.00	61.67	61.67
T_2	S_1C_2	46.67	43.33	43.33	43.33	53.33	55.00	50.00	50.00
T_3	S_1C_3	47.50	43.33	43.33	43.33	52.50	55.00	55.00	55.00
T_4	S_2C_1	79.67	78.83	78.83	78.83	20.33	18.67	18.67	18.67
T_5	S_2C_2	76.00	71.33	70.00	70.00	24.00	28.67	28.67	28.67
T_6	S_2C_3	44.00	42.67	42.67	42.67	56.00	56.00	57.33	57.33
T_7	S_3C_1	78.00	75.33	74.67	74.67	22.00	24.00	24.00	24.00
T_8	S_3C_2	72.67	68.00	68.00	68.00	27.33	30.00	30.00	30.00
T_9	S_3C_3	88.00	82.00	82.00	82.00	12.00	18.00	18.00	18.00
S.Em.±		2.331	2.508	2.883	2.883	2.331	2.934	3.300	3.300
C.D. at 5%		6.93	7.45	8.57	8.57	6.93	8.72	9.81	9.81
C.V. %		6.40	7.25	8.37	8.37	10.93	13.09	14.98	14.98

Conclusion

On the basis of results obtained from the present investigation, it can be concluded that grafts prepared during February-March (Summer) have high success and survival rate with the lowest mortality and polyhouse condition gave better results in terms of success rate under study.

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