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Standardization of time and grafting method in custard apple (*Annona squamosa* L.) cv. Sindhan under South Gujarat condition

SB Panchal, CR Patel and HL Chaudhary

Abstract
The present investigation entitled "standardization of time and grafting method in custard apple (*Annona squamosa* L.) cv. Sindhan under South Gujarat condition" was carried out at Agriculture Experimental Station, Navsari Agricultural University, Paria, District Valsad, during the year 2015-2016. The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) and the twelve treatment combinations were replicated thrice. Grafting was done at monthly interval starting from 15th March up to 15th August through wedge and side grafting techniques on custard apple rootstocks raised in polythene bags and kept under 50 % shade-net house condition. The results regarding different grafting time indicated that grafting on 15th March or 15th April found favorable, whereas among the techniques, wedge grafting found superior over side grafting in terms of significantly less days for first sprouting of scions, higher number of sprouted grafts, sprouting percentage, scion length, number of primary branches and survival of grafts. The interactions of grafting time and methods of grafting revealed that custard apple grafts prepared either on 15th March or 15th April through wedge grafting sprouted earlier and more in numbers it also obtained superior growth rate at different intervals with higher survival.

Keywords: Custard apple, sprouted grafts, sprouting percentage, scion length

Introduction
Custard apple (*Annona squamosa* L.) is a delicious, commercially important minor fruit crop which is cultivated in tropical and sub-tropical climate. Comes under family Annonaceae and native of the West Indies but it has been cultivated since early times throughout Central America to Southern Mexico. Custard apple is a shrub or small unattractive tree, with erect, rounded or spreading crown and reach up to 15 to 35 ft. and trunk 25-35 cm thick. Softwood grafting in custard apple is easy, less expensive and can produce large number of grafts in less time [Joshi *et al.* (1999) [10], Joshi (2000) [11], Pawar *et al.* (2003) [18] and Kudumulwar *et al.* (2008)] [14]. As the success of grafting largely depends upon the climatic conditions prevailing at the place, the season of grafting varies from place to place depending upon the climatic conditions. During specific period, the climatic conditions are highly suitable for grafting and grafting performed during that period can be resulted in highest graft take. In South Gujarat, custard apple grafting is performed better during months of March to May (Chauvatia and Singh, 1999) [4]. However weather conditions during these months are variable so proper time should be known to the nurserymen so as to get higher success. The extent of success of budding and grafting depends mainly on time of propagation and bio-chemical constituents present in scion and root stock which affects callus formation at the graft union region.

Materials and Methods
The experiment was conducted at the Agriculture Experimental Station, Navsari Agricultural University, At & Po. Paria, Ta: Pardi, District- Valsad. For the experiment, the rootstocks were raised in polythene bags, containing media of well drained red lateritic soil + vermi compost (1:1) and kept under 50 % shade net house condition). The experiment was laid out in a Randomized Block Design (RBD) with factorial concept with three replications and twelve treatment combinations. There were twenty five plants per treatment, out of which five tagged plants were used for taking different observations in each treatment.
The experiment involved two grafting methods (wedge and side grafting) using scion sticks of custard apple cv. Sindhan and grafting was done at monthly interval starting from March *viz.*, 15th March, 15th April, 15th May, 15th June, 15th July and 15th August.

Results and Discussion

Days taken for first sprouting

Data presented in Table 1 indicated that days taken for first sprouting was influenced significantly by grafting time and grafting method. Grafting done on 15th March (T_1) recorded significantly least days (10.86) taken for sprout initiation of grafts. This may be due to favorable weather conditions. During this period, the scions should have high levels of carbohydrate and other biochemical constituents which was helped in early sprouting of scion. Similar results were reported by Chauvatia and Singh (1999) [4] in custard apple cv. Sindhan Local under Saurashtra condition. Among the different grafting methods, wedge grafting (M_1) took significantly less days (15.83) taken for sprout initiation than side grafting. This might be due to more contact area for callus formation and better interlocking of parenchyma cells in wedge grafting resulted in early callus bridge formation and earlier sprouting of scions. Such results were also observed by Kumar *et al.* (2014) [15] who recorded significantly lower days for bud sprouting in cleft grafting followed by side grafting in custard apple cv. Local.

Table 2 showed the M × T interaction effect of sprout initiation days. Treatment combination M_1T_1 noted significantly lowest days (10.54) for sprout initiation of grafts. This might be to the combined effect of favorable weather conditions prevailed during these months, in terms of high temperature and moderate humidity which supported active growth after the resting period therefore the plants were in good sap flowing conditions resulted in early sprouting. Similar results were also observed by Kumar *et al.* (2014) [15] in custard apple.

Number of grafts sprouted and sprouting percentage per treatment

Mean data presented in Table 1 indicated that number of sprouted grafts and sprouting percentage were significantly influence by grafting time. Significantly, the highest number of sprouted grafts (21.68) and sprouting percentage (86.73) were recorded in grafting time T_1. This might be due to good sap flow conditions as well as the presence of higher levels of carbohydrate and other biochemical constituents in scions which helped in early sprouting of scions after grafting. Similar results were observed by Chauvatia and Singh (1999) [4] and Khopade and Jadav (2013) [13] in custard apple and Bharad *et al.* (2006) [2] in jamun. Among the grafting methods, significantly higher number of sprouted grafts (17.01) and sprouting percentage (68.20) were recorded in wedge grafting. This might be due to early graft union formation owing to availability of more surface area to contact between cut portion of scion and root stock resulted in better callus proliferation and earlier union thereby higher number of sprouted scions in case of wedge grafting as compared to side grafting (Hartmann and Kester, 1986) [7]. Similar results were noted by Kumar *et al.* (2014) [15] in custard apple with cleft grafting as compared to side grafting and Misra (1985) [16] in pecan nut with whip grafting as compared to side grafting. Hiwale *et al.* (2010) [8] also recorded significantly higher graft success in softwood grafting in custard apple.

Table 3 showed the M × T interaction effect on numbers of graft sprouted and sprouting percentage. Significantly the highest numbers of grafts sprouted (21.70) and sprouting percentage (86.79) were noted in the treatment combinations of M_1T_1 (wedge grafting done on 15th March) and M_2T_2 (side grafting on 15th March). This might be fact that spring is the best season for grafting in warm region crops. During the month of March the custard apple plants starts their new growth which also favored by the climatic conditions at this period, as a result the sap flows at a higher rate in mother plants. Such favorable climatic conditions might also enhanced the early callus bridge formation & development of vascular cambium through which nutrients and water uptake can take place. Further, sufficient food materials present during March as well as biologically active conditions of the custard apple plants might be supported earlier sprouting in terms of higher grafts sprouted and sprouting percentage. Similar results were observed by and Kumar *et al.* (2014) [15] in custard apple and Chandra *et al.* (2011) [3] in pomegranate.

Number of primary branches

Mean data presented in Table 1 showed the grafting done on 15th March (T_1) gave significantly the highest (3.13) number of primary branches. The probable reason might be due to its higher carbohydrate content stored in turn utilized to continue the primary growth at a faster rate and resulted as higher graft height, scion length and primary branches for the grafts well as the climatic conditions also helped in maintaining the growth of grafts at a faster rate. Similar trend was observed by (Kumar and Shukla 2012) [26] who recorded significantly higher secondary branches in the month of May in custard apple at IGFRI, Jhansi. Among the methods of grafting, wedge grafting (M_1) recorded significantly highest (2.27) number of primary branches at 180 DAG. This may be differs for the cuts made to join the stock & scion in a way that wedge grafting involve two times higher area to contact with cut portions as compared to the side grafting method. This difference might be played leading role in formation of a union earlier which then supported growth of grafts at higher rate. Similar results were noted by Islam *et al.* (2004) [9] in mango and Zaen El Deen and Abd El Rhman (2011) [25] in pistachio.

The data presented in table 3 indicate the interaction effect of grafting time and grafting methods (T×M) with respect to number of primery branches. Significantly, the highest number of primary branches (3.51) was noted in the treatment combination of M_1T_1 (wedge grafting on 15th March). This may be due to the grafts which sprouted early also produced leaves early which then synthesized sugars to be used to maintain and increase growth. Similar trend was observed by Islam *et al.* (2004) [9] in mango and Rani Sohnika *et al.* (2015) [20] who recorded significantly higher shoots per plant in wedge grafting during September in guava.

Scion length

Data presented in Table 4 represent the length of scion which was significantly affected by grafting time at 60, 120 and 180 DAG. Among the different grafting time, T_2 recorded the highest scion length (35.96, 49.22, 69.79 cm) at 60, 120 and 180 DAG respectively. It is possible that synthesis of more food materials through photosynthesis that supported cell elongation & multiplication process which ultimately resulted in higher scion length. Similar results were observed by Chauvatia and Singh (1999) [4], Joshi *et al.* (2011) [12], Khopade and Jadav (2013) [13] and Pawar *et al.* (2003) [18] in custard apple and (Pampanna and Sulikeri 1995) [27] in sapota. Among the different grafting methods, significantly higher

scion length was recorded in wedge grafting (M_1) at 120 and 180 DAG (45.37 and 66.04 cm) respectively. This might be due to such graft union formation allowed uptake of water and nutrients early and more intensely which then supported early sprouting of scion which bear higher number of leaves and higher leaf area andfinally recorded higher scion length. Similar results were obtained by Abbas *et al.* (2013) [1] in guava, Islam *et al.* (2004) [9] in mango and Zaen El Deen and Abd El Rhman (2011) [25] in pistachio.

The interaction effects (Table 5) between grafting time and grafting methods on scion length were found to be significant at 60 and 180 DAG. The highest scion length (37.24 and 69.75cm) at 60 and 180 DAG, respectively was recorded by treatment combination M_1T_2 (wedge grafting done on 15th April) which was at par with the treatment combinations of M_1T_1 (wedge grafting on 15th March), M_2T_2 (side grafting on 15th April) and M_2T_1 (side grafting on 15th March). This may be due to sunny conditions which favored the process of photosynthesis and production of plant food at higher rate as compared to the later months. The plant food materials produced in higher quantity then utilized subsequently for cell elongation and cell multiplication in the scion shoots which expressed as higher graft height and length of scions. Similar results were observed by Chovatia and Singh (2000) [5] in jamun, Zaen El Deen and Abd El Rhman (2011) [25] in pistachio and Chandra *et al.* (2011) [3] in pomegranate.

Graft survival percentage

Table 6 represent the data of graft survival percentage. Significantly highest graft survival (88.84, 82.00 and 82.00 %) at 30, 60 and 90 DAG respectively were recorded when grafting done on 15th April. This may be attributed to the congenial weather conditions, which resulted in increased cell activity after grafting leading to better union of stock and scion. The plants have higher carbohydrate contents and are in physiologically active conditions with better sap flow that leads to higher graft survival percentage for the grafts. Similar results were observed by Venkataratanam and Satyanaranaswamy (1956) [24], Chauvatia and Singh (1999) [4], Joshi *et al.* (1999) [11] and Giri and Lenka (2008) [6] in custard apple, Singh and Sengupta (1996) [23] in mango, Bharad *et al.* (2006) [2] in Jamun and Shinde *et al.* (1996) [21] in tamarind. Among the different grafting methods, significantly higher graft survival (69.92, 66.19 and 66.19% at 30, 60 and 90 DAG, respectively were recorded in wedge grafting (M_1). This might be due to differs for the cuts made to join cambium layer in a way that wedge grafting involve two times higher surface area to contact between cut portion of scion and rootstocks as compared to side grafting which leads to the early callus bridge formation and subsequent differentiation of vascular cambium that resulted in higher graft survival percentage. These findings are supported by Kumar *et al.* (2014) [15] in custard apple, Islam *et al.* (2004) [9] in mango and Ogden *et al.* (1986) in sapota. Ramirez and Marin (2000) [19] also found 80 per cent success in cleft grafting in guava as against 70 per cent success in side veneer grafting.

Mean data presented in Table 7 indicated the interaction between grafting time and grafting methods (T × M) with respect to graft survival percentage at 60 and 90 DAG. Significantly highest graft survival (82.72 %) at 60 and 90 DAG was recorded with treatment combination M_1T_2. which was at par with the treatment combinations of M_1T_1, M_2T_2 and M_2T_1. The probable reason for that was higher sap flow condition of the mother plants along with congenial weather conditions prevailed during these time, provided ideal conditions for better union of cambium layer in stock and scion that leads to higher graft survival percentage for the grafts. Similar results were observed by Kumar *et al.* (2014) [15] in custard apple, Islam *et al.* (2004) [9] recorded higher survival percentage in modified cleft grafting in the month of June, Singh *et al.* (2012) [28] in mango and Chovatia and Singh (2000) [5] in jamun.

Conclusion

Among the different grafting time studied, grafting done during 15th March to 15th April through wedge grafting technique proved superior for the various parameters of grafts studied. The interactions between grafting time and methods of grafting revealed that the treatment combinations of M_1T_1 (wedge grafting on 15th March), M_1T_2 (wedge grafting on 15th April), M_2T_1 (side grafting on 15th March) and M_2T_2 (side grafting on 15th April) had recorded significantly less days for sprout initiation of scion, higher number of sprouted grafts, sprouting percentage, scion length, number of primary branches and survival of grafts.

Table 1: Effect of time and grafting method on success of grafting in custard apple (*Annona squamosa* L.)

Treatments	Days taken for first sprouting	No. of grafts sprouted	Sprouting percentage	Number of primary branches
	Time of grafting (T)			
T_1 : Grafting on 15th March	10.86	21.68	86.73	3.13
T_2 : Grafting on 15th April	13.80	18.83	75.33	2.58
T_3 : Grafting on 15th May	15.40	16.67	66.67	2.12
T_4 : Grafting on 15th June	17.94	15.67	62.67	1.82
T_5 : Grafting on 15th July	21.37	13.17	52.67	1.62
T_6 : Grafting on 15th August	23.78	9.83	39.33	1.15
S.E.M. ±	0.73	0.53	2.11	0.106
C.D. at 5 %	2.15	1.54	6.68	0.311
Method of grafting (M)				
M_1 : Wedge grafting	15.83	17.01	68.20	2.27
M_2 : Side grafting	18.55	14.94	59.78	1.87
S.E.M. ±	0.423	0.304	1.26	0.061
C.D. at 5 %	1.241	0.892	3.57	0.179

Table 2: Interaction effect of time and grafting method on days taken for first sprouting

M × T	Wedge grafting M_1	Side grafting M_2
T_1- 15th March	10.54	11.19
T_2- 15th April	11.63	15.96
T_3- 15th May	11.99	18.81
T_4- 15th June	16.60	19.27
T_5- 15th July	20.91	21.83
T_6- 15th August	23.33	24.24
S.E.M. ±	1.037	
C.D. at 5%	3.040	
C.V. %	10.44	

Table 3: Interaction effect of time and grafting method on No. of grafts sprouted, sprouting percentage and number of primary branches.

M × T	days taken for first sprouting		No. of grafts sprouted		Sprouting percentage		Number of primary branches	
	M_1	M_2	M_1	M_2	M_1	M_2	M_1	M_2
T_1- 15th March	10.54	11.19	21.70	21.67	86.79	86.67	3.51	2.76
T_2- 15th April	11.63	15.96	19.33	18.33	77.33	73.33	2.83	2.33
T_3- 15th May	11.99	18.81	18.33	15.00	73.33	60.00	2.07	2.17
T_4- 15th June	16.60	19.27	18.00	13.33	72.00	53.33	2.03	1.60
T_5- 15th July	20.91	21.83	14.33	12.00	57.33	48.00	2.00	1.23
T_6- 15th August	23.33	24.24	10.33	9.33	41.33	37.33	1.20	1.10
S.E.M. ±	1.037		0.745		2.98		0.150	
C.D. at 5 %	3.040		2.185		8.74		0.439	
C.V. %	10.44		8.08		8.08		12.53	

Table 4: Effect of time and grafting method on scion length of custard apple

Treatments	Scion length (cm)		
	60th DAG	120th DAG	180th DAG
Time of grafting (T)			
T_1: Grafting on 15th March	33.80	47.15	68.79
T_2: Grafting on 15th April	35.96	49.22	69.67
T_3: Grafting on 15th May	32.36	45.01	64.20
T_4: Grafting on 15th June	29.90	43.15	62.79
T_5: Grafting on 15th July	28.53	41.32	62.47
T_6: Grafting on 15th August	27.26	39.78	55.76
S.E.M. ±	0.88	1.26	1.69
C.D. at 5 %	2.58	3.69	4.95
Method of grafting (M)			
M_1 : Wedge grafting	32.04	45.37	66.04
M_2 : Side grafting	30.56	43.17	61.86
S.E.M. ±	0.508	0.725	0.974
C.D. at 5 %	NS	2.128	2.856
Interaction (M x T)			
S.E.M. +	1.245	1.777	2.386
C.D. at 5 %	3.652	NS	6.997
C.V. %	6.89	6.95	6.46

Table 5: Interaction effect of time and grafting method on length of scion after 60 and 180 days after grafting

M × T	60th DAG		180th DAG	
	M_1	M_2	M_1	M_2
T_1- 15th March	34.71	32.88	68.78	68.78
T_2- 15th April	37.24	34.68	69.75	69.58
T_3- 15th May	32.93	31.80	68.00	60.40
T_4- 15th June	29.74	30.05	67.54	58.04
T_5- 15th July	27.30	29.75	67.55	57.39
T_6- 15th August	30.33	24.19	54.59	56.93
S.E.M. ±	1.25		2.39	
C.D. at 5 %	3.65		6.99	
C.V. %	6.89		6.46	

Table 6: Effect of time and grafting method in graft survival percentage on custard apple cv. Sindhan

Treatments	Graft survival percentage		
	30th DAG	60th DAG	90th DAG
Time of grafting (T)			
T1: Grafting on 15th March	82.08	79.58	79.58
T2: Grafting on 15th April	88.84	82.00	82.00
T3: Grafting on 15th May	68.83	63.83	63.83
T4: Grafting on 15th June	63.83	59.33	59.33
T5: Grafting on 15th July	51.00	49.00	49.00
T6: Grafting on 15th August	42.50	37.83	37.83
S.E.M. ±	2.12	2.05	2.05
C.D. at 5 %	6.21	6.01	6.01
Methods of grafting (M)			
M1: Wedge grafting	69.92	66.19	66.19
M2: Side grafting	62.45	57.67	57.67
S.E.M. ±	1.222	1.184	1.184
C.D. at 5 %	3.585	3.472	3.472
Interaction (M x T)			
S.E.M. ±	2.99	2.90	2.90
C.D. at 5 %	NS	8.51	8.51
C.V. %	7.84	8.11	8.11

Table 7: Interaction effect of time and grafting method on graft survival percentage on custard apple cv. Sindhan

M × T	60th DAG		90th DAG	
	M1	M2	M1	M2
T1- 15th March	81.74	77.43	81.74	77.43
T2- 15th April	82.72	81.28	82.72	81.23
T3- 15th May	72.12	55.55	72.12	55.55
T4- 15th June	66.31	52.35	66.31	52.35
T5- 15th July	55.46	42.54	55.46	42.54
T6- 15th August	38.82	36.85	38.82	36.85
S.E.M. ±	2.900		2.900	
C.D. at 5 %	8.505		8.505	
C.V. %	8.11		8.11	

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