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Effect of grafting time and 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 favourable, whereas among the techniques, wedge grafting found superior over side grafting in terms of significantly less days for first sprouting of scions, higher total number of leaves, leaf area, height of graft, scion girth and survival of grafts. The interactions of periods and methods of grafting revealed that custard apple grafts prepared either on 15th March to 15th April through wedge grafting sprouted earlier & more in numbers, obtained superior growth rate at different intervals with higher survival.

Keywords: Custard apple, weather conditions, vascular tissues, *Annona squamosa* L, grafting techniques

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 upto 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

Mean data presented in Table 1 indicated that days taken for first sprouting was influenced significantly. Among the different grafting time, grafting done on 15th March (T_1) recorded significantly least (10.86) days taken for first sprouting of grafts. This may be due to the favourable weather conditions. During this period, the scions should have high levels of carbohydrate and other biochemical constituents which might be 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 studied, plants grafted by wedge grafting (M_1) took significantly less (15.83) days taken for first sprouting 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 1: Effect of time and grafting method on success of grafting in custard apple (*Annona squamosa* L.)

Treatments	Days taken for first sprouting	Total no. of leaves		
		60th DAG	120th DAG	120th DAG
Time of grafting (T)				
T_1 : Grafting on 15th March	10.86	9.97	14.20	19.57
T_2 : Grafting on 15th April	13.80	10.80	16.93	21.63
T_3 : Grafting on 15th May	15.40	8.40	13.83	18.43
T_4 : Grafting on 15th June	17.94	6.87	13.37	17.93
T_5 : Grafting on 15th July	21.37	5.77	11.83	16.90
T_6 : Grafting on 15th August	23.78	4.30	10.78	16.67
S.E.M. ±	0.73	0.38	0.74	0.54
C.D. at 5 %	2.15	1.11	2.18	1.58
Methods of grafting (M)				
M_1 : Wedge grafting	15.83	8.50	14.16	18.99
M_2 : Side grafting	18.55	6.87	12.83	18.06
S.E.M. ±	0.423	0.219	0.427	0.311
C.D. at 5 %	1.241	0.643	1.251	0.914

The treatment combinations of wedge grafting done on 15th March (M_1T_1) expressed as significantly lowest (10.54) number of days for first sprouting of grafts. This might be to the combined effect of favourable weather conditions prevailed during these months, in terms of high temperature & moderate humidity which supported active growth after the resting period due to which the plants were in good sap flowing conditions resulted in less days to first sprouting. Simiar results were also observed by Kumar *et al.* (2014) [15] in custard apple.

Total number of leaves

Total number of leaves per grafts was significantly higher when grafting done on 15th April (T_2). This may be due to the fact that during winter months the custard apple plants undergo resting during which the food materials in mother plants increase considerably (Chauvatia and Singh, 1999) [4]. In the month of March-April, custard apple plants start their new growth during which the stored food materials utilized to produce leaves which then start photosynthesis thereby, contribute to the increasing food requirement of the growing plant. When such scions with possibly higher quantity of stored food materials used for grafting, they sprouted early. Good sap flow conditions of plants and favourable climate might have favoured the healing process and established the continuity of cambial and vascular tissues for the graft take resulted in earlier sprouting of grafts, thereby produced higher number of leaves as compared to the grafts prepared during later months. Similar results were also obtained by Chauvatia and Singh (1999) [4], Joshi *et al.* (2011) [12] and Khopade and Jadav (2013) [13] in custard apple and (Pampanna and Sulikeri 1995) [26] in sapota.

Among the grafting methods, significantly higher total number of leaves per grafts was recorded in wedge grafting (M_1). More number of leaves per grafts exhibits a sign of better growth. Probably, more cambium contact between stock and scion in wedge grafting might be contributed in early callus development leading to quicker repair of broken cells leading to early union development and thereby increased number of leaves on grafts as compared to the side grafting. (Hema *et al.* 2002) [27] recorded higher number of leaves in wedge grafting in mango. Similar findings were also noted by (Singh *et al.* 2012) [28], Abbas *et al.* (2013) [1] in mango, Rani Sohnika *et al.* (2015) [20] in guava.

Significantly higher number of leaves per graft were recorded when wedge grafting done on 15th April (M_1T_2) and side grafting done on 15th April (M_2T_2). This may be due to both, favourable climatic conditions prevailed during that period as well as higher food reserve in plants leading to early sprouting of scions that supported growth of the grafts at higher rate during April and resulting in production of higher number of leaves on the grafts. These findings are supported by Islam *et al.* (2004) [9] who recorded significantly higher number of leaves in mango cultivars 'Amrapalli' and 'Gopalbhog' in the month of June at Bangladesh condition.

Leaf area (cm^2)

Significantly higher total leaf area was recorded when grafting done on 15th April and 15th March (T_2 & T_1). Higher leaf area is directly correlated with higher number of leaves per grafts recorded during these months possibly due to higher stored food in scions and favourable climatic conditions that facilitated higher rate of growth among grafts (Table 3). Rani Sohnika *et al.* (2015) [20] who recorded significantly higher leaf area in the month of August in guava at Udheywalla, Jammu & Kashmir; and, Angadi and Karadi (2012) recorded significantly higher leaf area in the month of June in jamun at UAS, Dharwad.

Table 2: Interaction effect of time and methods on success of grafting in custard apple (*Annona squamosa* L.)

Interactions	Days taken for first sprouting	Total no. of leaves		
		60th DAG	120th DAG	180th DAG
M1T1	10.54	11.27	14.93	18.07
M1T2	11.63	12.53	17.27	22.07
M1T3	11.99	8.13	16.40	19.73
M1T4	16.60	7.40	11.67	18.87
M1T5	20.91	6.80	13.27	17.87
M1T6	23.33	4.87	11.40	17.33
M2T1	11.19	8.67	13.47	21.07
M2T2	15.96	9.07	16.60	21.20
M2T3	18.81	8.67	11.27	17.13
M2T4	19.27	6.33	15.07	17.00
M2T5	21.83	4.73	10.40	15.93
M2T6	24.24	3.73	10.17	16.00
S.E.M. ±	1.037	0.537	1.045	0.763
C.D. at 5 %	3.040	1.576	3.065	2.238
CV %	10.44	12.11	13.42	7.13

Table 3: Effect of time and grafting method on success of grafting in custard apple (*Annona squamosa* L.)

Treatments	Leaf area (cm^2)			Height of graft (cm)		
	60th DAP	120th DAP	180th DAP	60th DAP	120th DAP	180th DAP
Time of grafting (T)						
T1: Grafting on 15th March	29.91	48.08	66.14	50.13	58.21	77.32
T2: Grafting on 15th April	32.93	53.86	69.89	51.99	61.37	83.11
T3: Grafting on 15th May	26.71	46.75	62.24	48.45	56.55	75.13
T4: Grafting on 15th June	23.65	33.13	49.36	46.30	54.05	71.53
T5: Grafting on 15th July	21.98	25.66	45.14	43.64	52.12	69.34
T6: Grafting on 15th August	20.71	23.13	40.38	41.43	49.53	67.21
S.E.M. +	0.89	1.84	2.74	1.85	2.48	3.12
C.D. at 5 %	2.61	5.41	8.02	5.42	7.26	9.16
Methods of grafting (M)						
M1 : Wedge grafting	26.77	40.62	58.67	48.57	59.27	77.39
M2 : Side grafting	25.19	36.26	52.38	45.41	51.34	70.49
S.E.M. +	0.515	1.064	1.579	1.067	1.430	1.803
C.D. at 5 %	1.509	3.121	4.632	3.131	4.194	5.288

Among the grafting methods, significantly higher leaf area was recorded in wedge grafting (M_1). This might be correlated with enhanced union of rootstocks and scion in plants grafted through wedge technique leading to better vegetative growth in terms of higher number of leaves and leaf area in such plants. The findings of Hiwale *et al.* (2010) [8] also support who recorded maximum leaf area in softwood grafting followed by budding in custard apple and Rani Sohnika *et al.* (2015) [20] who recorded significantly higher leaf area in wedge grafting followed by layering in guava.

Significantly higher leaf area was recorded in the treatment combination of M_1T_2 (wedge grafting done on 15th April) which was at par with the treatment combinations of M_2T_2 and M_2T_1. The probable reasons might be attributed to favourable climatic conditions that enhanced earlier sprouting of scions as well as the higher food reserve in custard apple plants also utilized to initiate and maintain higher number of leaves which produced more food materials (carbohydrate) for grafts and expressed as better growth in terms of higher leaf area in grafts grafted during March-April.

Height of graft (cm)

Among the different grafting time, significantly higher height of grafts was recorded when grafting done on 15th April and 15th March (T_2 & T_1). This may be due to the fact that temperature plays an important role in photosynthetic activity of the leaves and subsequent growth of plants. Custard apple plants grafted in March-April received higher temperature at 60 and 120 days after grafting that supported higher photosynthetic activity leading to production of photosynthetic carbohydrate which utilized to maintain higher growth rate in terms of number of leaves & leaf area as well as grafts height up to 180 DAG. It is also possible that higher number of leaves recorded in the grafts grafted during March-April produced sufficient photosynthetic food materials to grow grafts with higher height. Similar results were observed by Chauvatia and Singh (1999) [4] and Khopade and Jadav (2013) [13] in custard apple and Shinde *et al.* (1996) [21] in tamarind. Patel *et al.* (2010) [17] recorded higher plant height in 'Khasi' mandarin grafted on July 30 as compared to the grafting during September-October at Horticultural Research Farm, ICAR-NEH, Umiam, Meghalaya due to higher temperatures during July.

Among the different grafting methods, significantly higher height of graft was recorded in wedge grafting (M_1). This may be directly linked with the cut made for grafting in both the methods. In wedge grafting, vertical downward cut in stock naturally provide strong contact with scions and the region for cambium bridge is almost double than that of side grafting. It might be possible that union of stock and scion will formed earlier in wedge grafted plants and resulted in earlier resumption of growth with higher height in wedge grafting. Similar results were also obtained by Abbas *et al.* (2013) [1] in guava and Hiwale *et al.* (2010) [8] who recorded maximum leaf area in softwood grafting followed by budding in custard apple.

Significantly, the highest height of grafts was recorded in the treatment combination of M_1T_2 (wedge grafting done on 15th April) and which was at par with treatment combination of M_2T_2 (side grafting on 15th April), M_1T_1 (wedge grafting on 15th March) and M_2T_1 (side grafting on 15th March). The favourable climatic conditions during March-April definitely increased the rate of photosynthesis and leads to formation of more food materials that supported higher rate of growth in the grafts that might facilitated earlier union formation and subsequent growth during initial periods and lasts during later stages to produce grafts with higher height. Similar results were observed by Islam *et al.* (2004) [9] in mango.

Scion girth (cm)

Among the different grafting time, significantly higher scion girth was recorded when grafting done on 15th March and 15th April (T_1&T_2). During the months of March-April, custard apple plants starts their new growth during which the stored food materials utilized to produce new leaves which then start photosynthesis; thereby, contribute to the food requirement of the growing plant. The higher quantity of stored food materials facilitated early sprouting, led to production of more number of leaves and synthesis of food which can be utilized to induce higher rate of growth in terms of higher plant height as compared to the grafts grafted in later months. The increment in girth can be correlated with graft height and it is obvious that the grafts with higher height also have higher girth in a particular mass of plants kept at uniform climatic conditions. Therefore, it is acceptable that the grafts with higher height also recorded higher scion girth in the present

investigation. Similar results were observed by Chauvatia and Singh (1999) [4] and Kudmulwar *et al.* (2008) [14] in custard apple and Hiwale *et al.* (2008) [8] in wood apple. Patel *et al.* (2010) [17] recorded higher scion diameter in 'Khasi' mandarin grafted on July 30 as compared to the grafting during September-October at Horticultural Research Farm, ICAR-NEH, Umiam, Meghalaya due to higher temperatures during July.

Among the different grafting methods, significantly higher scion girth was recorded in wedge grafting (M_1). This may be due to more cambium contact between the cut portion of stock and scion in wedge grafting that contributed in early callus development leading to quicker repair of broken cells resulting in early union development and thereby, maintained increased rate of growth in terms of higher number of leaves, leaf area, height of graft and girth of scion as compared to the side grafting. Similar results were obtained by Zaen El Deen and Abd El Rhman (2011) [25] in pistachio and Hiwale *et al.* (2010) [8] who recorded maximum leaf area in softwood grafting followed by budding in custard apple.

The higher scion girth was recorded by grafts from the treatment combinations of M_1T_2 (wedge grafting done on 15th April) and M_2T_1 (side grafting on 15th March) which was at par with the treatment combinations of M_1T_3, M_1T_4, M_1T_5, M_1T_6, M_2T_2, M_2T_3 and M_2T_4. This may be due to during March-April, the higher quantity of stored food materials present in scions facilitated early sprouting and production of more number of leaves with higher leaf area (Table 4; 5; 6). The increased food production units *i.e.* leaves synthesized higher quality of food which equally supported by desirable temperature prevailed after grafting during March-April and that food materials utilized to support and maintain higher rate of growth in terms of graft height and scion girth in plants grafted during the months of March-April in both the months of grafting. These findings are supported by Rani Sohnika *et al.* (2015) [20] in guava, Chovatia and Singh (2000) [5] in jamun and Chandra *et al.* (2011) [3] in pomegranate.

Table 4: Interaction effect of time and methods on success of grafting in custard apple (*Annona squamosa* L.)

Interactions	Leaf area (cm^2)	Height of graft (cm)	
	120th DAG	60th DAG	180th DAG
M_1T_1	47.52	47.07	73.15
M_1T_2	55.48	47.57	83.79
M_1T_3	51.25	48.33	79.74
M_1T_4	35.59	51.85	77.78
M_1T_5	32.90	48.73	80.53
M_1T_6	20.95	47.88	69.35
M_2T_1	48.64	53.19	81.48
M_2T_2	52.25	56.40	82.44
M_2T_3	42.25	48.56	70.52
M_2T_4	30.67	40.75	65.27
M_2T_5	18.42	38.54	58.15
M_2T_6	25.31	34.98	65.07
S.E.M. ±	2.606	2.615	4.416
C.D. at 5%	7.644	7.669	12.953
C.V. %	11.75	9.64	10.35

Table 5: Effect of time and grafting method on success of grafting in custard apple (*Annona squamosa* L.)

Treatments	Scion girth (cm)			Grafts survival percentage (%)		
	60th DAP	120th DAP	180th DAP	30th DAP	60th DAP	90th DAP
Time of grafting (T)						
T_1: Grafting on 15th March	0.40	0.69	0.87	82.08	79.58	79.58
T_2: Grafting on 15th April	0.37	0.61	0.85	88.84	82.00	82.00
T_3: Grafting on 15th May	0.36	0.60	0.83	68.83	63.83	63.83
T_4: Grafting on 15th June	0.35	0.59	0.80	63.83	59.33	59.33
T_5: Grafting on 15th July	0.32	0.56	0.79	51.00	49.00	49.00
T_6: Grafting on 15th August	0.29	0.55	0.75	42.50	37.83	37.83
S.E.M. ±	0.02	0.02	0.02	2.12	2.05	2.05
C.D. at 5 %	0.05	0.06	0.06	6.21	6.01	6.01
Methods of grafting (M)						
M_1: Wedge grafting	0.36	0.63	0.83	69.92	66.19	66.19
M_2: Side grafting	0.34	0.57	0.80	62.45	57.67	57.67
S.E.M. ±	0.009	0.012	0.013	1.222	1.184	1.184
C.D. at 5 %	NS	2.128	2.856	3.585	3.472	3.472

Table 6: Interaction effect of time and methods on success of grafting in custard apple (*Annona squamosa* L.)

Interactions	Scion girth (cm)		Graft survival (%)	
	60th DAG	180th DAG	60th DAG	90th DAG
M_1T_1	0.40	0.86	81.74	81.74
M_1T_2	0.37	0.81	82.72	82.72
M_1T_3	0.36	0.83	72.12	72.12
M_1T_4	0.34	0.85	66.31	66.31
M_1T_5	0.35	0.81	55.46	55.46
M_1T_6	0.35	0.82	38.82	38.82
M_2T_1	0.40	0.89	77.43	77.43
M_2T_2	0.36	0.88	81.28	81.28
M_2T_3	0.36	0.82	55.55	55.55
M_2T_4	0.37	0.75	52.35	52.35
M_2T_5	0.29	0.77	42.54	42.54
M_2T_6	0.23	0.68	36.85	36.85
S.E.M. ±	0.023	0.031	2.900	2.900
C.D. at 5%	0.068	0.091	8.505	8.505
C.V. %	11.46	6.58	8.11	8.11

Graft survival percentage

Among the different grafting time, significantly higher graft survival (88.84, 82.00 and 82.00 % at 30, 60 and 90 DAG) was 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. Majumder *et al.* (1972) [29] reported 90 % success on grafting using scions taken from non-flowering shoots compared with 70 % success from flowering shoots. Similar results were observed by Venkataratanam and Satyanaranaswamy (1956) [24], Chauvatia and Singh (1999) [4], Joshi *et al.* (1999) [10] 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. Patel *et al.* (2010) [17] recorded higher plant survival in 'Khasi' mandarin grafted on July 30 as compared to the grafting during September-October at Horticultural Research Farm, ICAR-NEH, Umiam, Meghalaya due to higher temperatures during July.

Among the different grafting methods, significantly higher graft survival (69.92, 66.19 and 66.19 % at 30, 60 and 90 DAG, respectively) was recorded for 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) [7] 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.

The interaction effects between grafting time and grafting methods were found significantly influenced on grafts survival percentage at 60 and 90 DAG. Significantly higher graft survival (82.72 % at 60 and 90 DAG) was recorded when wedge grafting done on 15th April (M_1T_2) which was at par with the treatment combinations of M_1T_1, M_2T_2 and M_2T_1. The 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) [30] 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; whereas among the methods, grafting done through wedge grafting technique proved superior for the various parameters of grafts studied. The interactions of periods 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 first sprouting of scion, higher total number of leaves, leaf area, height of graft, scion girth and survival of grafts were also significantly higher in the grafts grafted during 15th March to 15th April through either wedge or side grafting method under 50% shade-net house condition.

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