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Effect of method and time of grafting on bud sprouting percentage, time of leaf burst, total number of branches and leaf length of kiwifruit under temperate conditions of Kashmir

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Abstract
The present studies entitled "Studies on vegetative propagation techniques in kiwifruit under Kashmir conditions" was carried out in the experimental farm, Division of Fruit Science during 2017 and 2018. The experiment was laid out in a Completely Randomized block Design with three replications. In this experiment, three methods of grafting (cleft, tongue and whip) were performed on three different dates (3rdweek of February, 1st week of March and 3rd week of March) with Hayward/Tomuri grafted on 2 years old seedling rootstock under field conditions. The results indicated that bud sprouting percentage (74.68), time of leaf burst(38.86 days after date of grafting), number of branches (3.70) and leaf length (9.45cm) were significantly better with cleft grafting followed by tongue grafting (71.55, 40.78, 3.75 and 9.31cm respectively). Bud sprouting percentage (72.85), Time of leaf burst (38.6 days after date of grafting), number of branches per plant (3.85) and leaf length 9.53cm) were significantly better during 3rd week of March followed by 1st week of March(71.02, 39.9, 3.52 and 9.27cm respectively. The interaction between method and type of scion was found significant for different parameters under study except number of branches. From this experiment it can be concluded that among different methods, time and scion type used, cleft grafting performed during 3rd week of March with Hayward cultivar significantly influenced bud sprouting percentage (82.3), time of leaf burst (35.8 days after date of grafting), number of branches (4.2) and leaf length (10.6 cm).

Keywords: Vegetative propagation, Hayward, grafting, Tomuri

Introduction
The kiwifruit, also known as Chinese gooseberry (*Actinidia deliciosa* Chev.), is a member of family *Actinidiaceae* with the chromosome number 2n= 58. It is a deciduous, dioecious vine fruit crop. It is being successfully grown and marketed in the world and is one of the most important fruit crop in the world. Its place of origin is Yangtze valley of south and central China (Ferguson, 1984) [8], where it is grown wild as well as in cultivated form (Lee, 1990) [11]. From its native place, it was first introduced in New Zealand and Europe in early 20th century and is presently cultivated on a large scale in different countries of world like New Zealand, China, Italy, USA, France, Germany, Japan, Australia and South Africa. Italy is the largest producer of kiwifruit in world followed by New Zealand and Chile (FAOSTAT, 2017) [7].
Kiwifruit is one of the best known nutritious fruit amongst the group of soft berries. 100g green kiwifruit provides 61 calories, 83% water and 15% carbohydrates, with negligible protein and fat. It is also used for meat tenderization. Kiwifruit when ripe, contain proteolytic enzyme actinidin, which is said to aid in digestion. Actinidin also makes raw kiwifruit unsuitable for use in desserts containing milk or any other dairy products because the enzyme digests milk proteins.
In India, it was first planted in Lal Bagh Garden at Bangalure in 1960s and did not fruit there due to lack of chilling requirement. Later on it was introduced at National Bureau of Plant Genetic Resource, Phagli, Shimla (Himachal Pradesh) where it was grown successfully (Dadlani *et al*., 1971) [4]. It has gained commercial importance in mid and low hills of entire Himalyan region because of high economic returns per unit area. The kiwifruit can be grown in most temperate climates with adequate summer heat. Its cultivation has now started in the states of Uttarakhand, Arunachal Pradesh, Meghalya, Nagaland and Nilgiri hills of South India
Kiwifruit can be propagated vegetatively, either through cutting (softwood and hardwood) or grafting and budding (Sale, 1985; Lawes, 1992) [15, 10]. However, root quality of shoots propagated by cutting is inferior than those propagated by grafting methods

(Diaz and Berrios, 1997) [5] and thus these plants make such a poor root system that they are difficult to transplant and therefore success percentage is lower. As a result very less number of plants are produced which are relatively negligible against a very huge demand. However, plants produced through grafting are vigorous with longer roots than those produced by cutting thus improves the transplanting success and finally increases success percentage (Ozcan, 2000) [14]. It also hastens the plant growth rate and reduces nursery production time.

In Kashmir, being a new crop, and there is a huge demand for kiwifruit plants, however the supply of adequate plant material of kiwifruit is limited. Therefore, for large scale multiplication of kiwifruit the present study was conducted to propagate kiwifruit through grafting to standardize the suitable method and time of grafting for kiwifruit.

Materials and Methods

The present investigations on "Studies on vegetative propagation of kiwifruit in Kashmir conditions" were carried out at experimental fields of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Shalimar Campus, during the year 2017-2018. Plant material used for the studies consists of Bruno cultivar of kiwifruit used as rootstock. The scion wood was collected from semi-mature current season's shoots of Hayward and Tomuri cultivar of kiwifruit. These bud sticks were defoliated immediately after collection from the trees. Tongue grafting, cleft grafting and whip grafting were performed as methods of grafting on three different dates and 1-1.5 cm wide strips of 400 gauge alkathane were used as the tying material in all the treatments.

The experiment was laid out in a randomized block design with 3 replications and 20 plants per replication. The data of bud sprouting percentage was calculated on the basis of number of grafs/buds sprouted out of the total number of grafts made under each treatment. The extent of scion bud bursting was recorded visually. The first bud of scion that broke into growth was observed and the average time taken by a scion bud to burst from date of grafting was worked out and was expressed as the number of days taken by scion bud to burst after the date of grafting. Total number of branches of ten randomly selected plants was counted and the mean number of branches per plant was worked out by dividing the total number of branches by ten. Fully expanded leaves were selected randomly from the grafted plants in the month of July. The leaf length was measured with the help of ruler and was expressed as cm per leaf.

Results and discussion

(1) Bud sprouting percentage

The data on effect of time of grafting, method of grafting and scion type on bud sprouting percentage are presented in Table 1.

From this data, it is evident that the percentage of bud sprouting was significantly influenced by time, method of grafting and scion type. The data in the table 1 indicate that grafting performed during 3rd week of March resulted in the highest bud sprouting percentage (72.85) followed by 3rd week of February (71.05) which is statistically at par with grafting performed on 1st week of March (71.02). This may be due to the rapid regeneration of cambium tissue due to the activation of rootstock and scion coupled with ideal temperature in mid- March. These results are in conformity with Srivastava (2012) [16] who found the similar results in walnut.

The methods of grafting indicate a significant influence on bud sprouting percentage. Cleft grafting exhibited the highest bud sprouting percentage (74.65) followed by tongue grafting (71.55) and the lowest bud sprouting percentage (68.65) was observed with whip grafting. It may be due to the maximum cambial contact between scion and rootstock. The earlier formation of cambial tissue between stock and scion increased the percentage of graft sprouting and development of new flushes on the sprout. These results are in conformity with Zenginbal (2015) [20] and Taiz and Zeiger (2012) [17] who found the similar results in kiwifruit Bud sprouting percentage was significantly influenced by scion type used. The maximum bud sprouting percentage (74.30) was recorded with scion Hayward (S_1) whereas minimum bud sprouting percentage (68.90) was observed with scion Tomuri (S_2). This may be due to better graft shoot quality of Hayward than Tomuri cultivar. These results are in conformity with Zenginbal (2007) [20] who observed the similar results in kiwifruit

Interaction between time x method had a significant influence on bud sprouting percentage. The maximum bud sprouting percentage was recorded with cleft grafting performed during 3rd week of March (75.55) followed by cleft grafting performed during 3rd week of February (74.65) and the lowest bud sprouting percentage (67.65) was observed with whip grafting performed during 1st week of March. A significant influence was observed in the interaction between method and scion type with the highest bud sprouting percentage (80.90) recorded in cleft grafting with scion Hayward (S_1) followed by tongue grafting (72.30) with scion Hayward (S_1) and lowest mean graft sprouting percentage (67.40) was observed in whip grafting with scion Tomuri (S_2). This is in conformity with Zengibal (2007) [20] who found the similar results in kiwifruit Interaction between time x scion and time x method x scion showed non-significant influence on graft sprouting percentage.

Table 1: Effect of time, method of grafting and scion type on percentage of bud sprouting in kiwifruit.

Method Scion Time	G1(Tongue grafting)		Submean	G2(Cleft grafting)		Submean	G3(Whip grafting)		Submean	Mean	Factor mean	
	S1	S2		S1	S2		S1	S2			S1	S2
T1 (3rd week of Feb.)	70.50	70.40	70.45	80.10	69.20	74.65	68.80	67.30	68.05	71.05	73.10	68.90
T2 (1st week of March)	72.20	70.90	71.55	80.40	67.30	73.85	68.60	66.70	67.65	71.02	73.70	68.30
T3 (3rd week of March)	74.20	71.10	72.65	82.30	68.80	75.55	71.90	68.40	70.15	72.85	76.10	69.40
Mean	72.30	70.80	71.55	80.90	68.40	74.68	69.70	67.40	68.65		74.30	68.90

S1 = Hayward, S2 = Tomuri
Main effect and interaction effect
CD (P=0.05)
Time (T) = 0.660
Method (M) = O.660
Scion (S) = 0.53
Time x Method (T x M) =1.14
Time x Scion (T x S) = NS
Method x Scion (M x S) = 0.933
Time x method x scion (T x M x S) = NS

(2) Time of leaf burst

The data on effect of time, method of grafting and scion type on time of leaf burst is presented in Table 2.

From this data, it is evident that time of leaf burst was significantly influenced by time of grafting, method of grafting and scion type. The data in the table 2 indicate that grafting performed during 3rd week of March took minimum number of days (38.60 DARD) for leaf bursting followed by grafting performed during 1st week of March(39.93 DARD) and the grafting performed during 3rd week of February took maximum number of days (40.80 DARD) for leaf bursting. It may be due to the fact that the favourable temperature and relative humidity at this time and rapid sap flow in stock and scion favoured the healing process and establishment of cambial and vascular tissues for graft take. These results are in conformity with Joolka *et al*. (2001) [9], who also found the minimum days to leaf burst with grafting performed during 3rd week of March in pecan.

The methods of grafting indicate a significant influence on time of leaf burst. Cleft grafting took minimum number of days (38.86 DARD) for leaf bursting followed by whip grafting (39.68 DARD) and the maximum number of days (40.78 DARD) for leaf bursting was taken by tongue grafting. This may be attributed to the maximum cambial contact between scion and rootstock which causes the rapid callus formation. These results are in conformity with Muzafar and Kumar (2011) [13], who also found the minimum number of days to leaf burst with cleft grafting in Walnut.

A significant effect was observed in the interaction between method and scion type with the minimum number of days to leaf burst (38.13 DARD) recorded in cleft grafting with scion Hayward (S1) followed by whip grafting (39.60) with scion Tomuri(S2) and maximum number of days to leaf burst(41.36 DARD) was observed in tongue grafting with scion Tomuri (S2). This is in conformity with Muzafar and Kumar (2011) [13] and Zenginbal (2007) [20] who also found the similar results in kiwifruit.

Interaction between time x scion x method showed significant effect on time of leaf burst. Cleft grafting with scion Hayward (S1) performed during 3rd week of March took minimum number of days to leaf burst (35.80 DARD) followed by cleft grafting performed during 3rd week of March (37.60 DARD) with scion Tomuri(S2). The maximum number of days to leaf burst was observed in tongue grafting (42.60 DARD) with scion Tomuri (S2) performed during 3rd week of February. Scion type and interaction between time x scion and time x method did not significantly influence time of leaf burst in kiwifruit. This is in conformity with Muzafar and Kumar (2011) [13], Joolka *et al.* (2001) [9] and Zenginabal (2007) [20] in kiwifruit and walnut.

Table 2: Effect of time, method of grafting and scion type on time of leaf (DARD) burst in kiwifruit.

Method Scion Time	G1(Tongue grafting)		Submean	G2(Cleft grafting)		Submean	G3(Whip grafting)		Submean	Mean	Factor mean	
	S1	S2		S1	S2		S1	S2			S1	S2
T1 (3rd week of Feb.)	41.00	42.60	41.80	39.00	41.60	40.30	41.00	39.60	40.30	40.80	40.30	41.20
T2 (1st week of March)	40.20	41.50	40.85	39.60	39.60	39.60	39.30	39.40	39.35	39.90	39.70	40.10
T3 (3rd week of March)	39.40	40.00	39.70	35.80	37.60	36.70	39.00	39.80	39.40	38.60	38.06	39.10
Mean	40.20	41.36	40.78	38.13	39.60	38.86	39.76	39.6 0	39.68		39.35	40.13

S1 = Hayward, S2 = Tomuri # DARD: Reference date: Date of grafting.
Main effect and interaction effect
CD (P=0.05)
Time (T) = 0.57
Method (M) = 0.57
Scion (S) = NS
Time x Method (T x M) = NS
Time x Scion (T x S) = NS
Method x Scion (M x S) = 0.80
Time x Method x Scion (T x M x S) = 1.39

(3) Total number of branches per plant

The data on effect of time, method of grafting and scion type on number of branches per plant is presented in Table. 3

From this data, it is evident that number of branches per plant was significantly influenced by time of grafting, method of grafting and scion type. The data in the table 3 indicate that grafting performed during 3rd week of March resulted in the maximum number of branches per plant (3.85) followed by 3rd week of February (3.53) and the minimum number of branches per plant (3.50) was recorded in grafting performed

during 1st week of March. It may be due to the favorable temperature and humidity at that time. This is in conformity with Chandel *et al.* (1998) [1] who recorded that vegetative growth is maximum in the kiwifruit plants propagated at this time.

The methods of grafting indicate a significant influence on number of branches per plant. Cleft grafting resulted in maximum number of branches per plant (3.70) which is statistically at par with Tongue grafting (3.70) and the minimum number of branches (3.48) was observed with whip grafting. The maximum number of branches per plant with cleft grafting may be attributed to the maximum cambial contact between scion and rootstock. These results are in conformity with Cholid *et al.* (2014) [2] who found the maximum number of branches per plant with cleft grafting in physic nut.

Interaction between time x method had a significant effect on number of branches per plant The maximum number of branches per plant was recorded with cleft grafting performed during 3rd week of March (4.05) followed by cleft grafting performed during 3rd week of February (3.75)and the minimum number of branches per plant was observed with whip grafting (3.25)performed during1st week of March This is in conformity with Cholid *et al.* (2014) [2] and Chandel *et al.* (1998) [1] who observed the similar results in kiwifruit.

Interaction between time x scion had a significant influence on number of branches per plant. Maximum number of branches per plant (4.06) was recorded with grafting performed during 3rd week of March with scion Hayward (S_1) and the minimum number of branches per plant (3.50) was observed with grafting performed during 3rd week of February with scion Tomuri (S_2). This is in conformity with Marino (1990) [12] who recorded the more number of branches in Hayward cultivar than Tomuri in kiwifruit.

Interaction between time x scion x method showed significant effect on number of branches per plant. Cleft grafting with scion Hayward (S_1) performed during 3rd week of March showed the maximum number of branches per plant (4.20). The minimum number of branches per plant (3.00) was observed in whip grafting with Hayward (S_2) performed during 3rd week of February scion type. This is in conformity with Cholid *et al.* (2014) [2], Chandel *et al.* (1998) [1] and Marino (1990) [12] in kiwifruit.

Interaction between method x scion showed non-significant influence on number of branches per plant.

Table 3: Effect of time, method of grafting and scion type on number of branches per plant in kiwifruit.

Method Scion Time	G1(Tongue grafting)		Submean	G2(Cleft grafting)		Submean	G3(Whip grafting)		Submean	Mean	Factor mean	
	S_1	S_2		S_1	S_2		S_1	S_2			S_1	S_2
T_1 (3rd week of Feb.)	3.60	3.30	3.45	4.10	3.40	3.75	3.00	3.80	3.40	3.53	3.56	3.50
T_2 (1st week of March)	3.90	4.00	3.95	3.30	3.30	3.30	3.30	3.20	3.25	3.52	3.50	3.50
T_3 (3rd week of March)	4.10	3.30	3.70	4.20	3.90	4.05	3.90	3.70	3.80	3.85	4.06	3.73
Mean	3.86	3.53	3.70	3.86	3.53	3.70	3.40	3.56	3.48		3.62	3.54

S_1 = Hayward, S_2 = Tomuri
Main effect and interaction effect
CD (P=0.05)
Time (T) = 0.14
Method (M) = 0.148
Scion (S) = NS
Time x Method (T x M) = 0.256
Time x Scion (T x S) = 0.209
Method x Scion (M x S) = NS
Time x Method x Scion (T x M x S) = 0.362

(4) Leaf length (cm)

The data on effect of time, method of grafting and scion type used on Leaf length is presented in Table. 4. From the data, it is evident that leaf length was significantly influenced by time, method and scion type used. The data in the table indicate that grafting performed during 3rd week of March resulted in the maximum leaf length (9.53cm) followed by grafting performed during 1st week of March(9.27cm) and the minimum leaf length (9.00cm) was recorded in grafting performed during 3rd week of February. It may be due to favorable environmental conditions during this time, resulting in early callus formation. This is in conformity with Dimiri *et al.* (2002) [6] who observed the similar results in apple.

Methods of grafting indicate a significant influence on leaf length. Cleft grafting reported the highest value of leaf length (9.45cm) which was statistically at par with tongue grafting (9.31cm) and the whip grafting resulted in lowest value of leaf length (9.04cm). This may be due to the maximum cambial contact between scion and stock that results in more vegetative growth. This is in conformity with Upadhyay *et al.* (2017) [18] who recorded that cleft grafting in walnut resulted in maximum leaf area.

The scion type used also had a significant influence on leaf length. The highest value of leaf length (9.76cm) was observed with scion Hayward (S_1). It may be due to the early vegetative growth due to rapid callus formation in Hayward than in Tomuri. These results are in conformity with Zenginbal (2007) [20] who obtained the similar results in kiwifruit.

Interaction between time and method had a significant effect on leaf length. The maximum value of leaf length was recorded with cleft grafting performed during 1st week of March (9.80cm) and the lowest value of leaf length (8.73cm) was observed with whip grafting performed during 3rd week of February. These results are in conformity with Dimiri *et al.* (2002) [6] and Upadhyay *et al.* (2017) [18].

A significant effect was observed in the interaction between method and scion type with the maximum value of leaf length (10.26cm) in cleft grafting with scion Hayward (S_1) and the minimum value of leaf length (8.58cm) was observed in cleft grafting with scion (S_2) Tomuri. These results are in conformity with Upadhyay *et al.* (2017) [18] and Zenginbal (2007) [20]

Interaction between time x scion x method and time x scion showed non-significant effect on leaf length.

Table 4: Effect of time, method of grafting and scion type on leaf length (cm) in kiwifruit

Method / Scion Time	G1(Tongue grafting)		Submean	G2(Cleft grafting)		Submean	G3(Whip grafting)		Submean	Mean	Factor mean	
	S1	S2		S1	S2		S1	S2			S1	S2
T1 (3rd week of Feb.)	10.20	8.46	9.33	9.50	8.40	8.95	8.70	8.76	8.73	9.00	9.46	8.54
T2 (1st week of March)	9.10	8.75	8.92	10.70	8.90	9.80	9.40	8.80	9.10	9.27	9.73	8.81
T3 (3rd week of March)	9.90	9.50	9.70	10.60	8.60	9.60	9.80	8.80	9.30	9.53	10.10	8.96
Mean	9.73	8.90	9.31	10.26	8.58	9.45	9.30	8.78	9.04		9.76	8.77

S1 = Hayward, S2 = Tomuri
Main effect and interaction effect
CD (P=0.05
Time (T) = 0.197
Method (M) = 0.197
Scion (S)= 0.161
Time x method (T x M) = 0.342
Time x Scion (T x S) = NS
Method x Scion (M x S) = 0.279
Time x Method x Scion (T x M x S) = NS

Conclusion

The present investigation on the "Studies on vegetative propagation of kiwifruit in Kashmir conditions" revealed that among the different grafting methods studied, cleft grafting proved significantly better as compared to other methods of grafting. Time of grafting and scion type also showed significant influence on different characters studied. Cultivar Hayward cleft grafted during 3rd week of March showed increased bud sprouting percentage, time of leaf burst, total number of branches per plant and leaf length. Thus, cleft grafting performed during 3rd week of March should be practiced for large scale multiplication of kiwifruit in Kashmir conditions.

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