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Short communication

Budding and grafting time and height as determining factors for bud take and successive plant growth in some temperate fruits

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ABSTRACT

Seasonal effect of different grafting and budding methods performed at three heights on pome, stone and nut fruits were studied under polyhoused condition. Chip budding at height of 8-10 cm and even 13-15 cm during February-March and July-August was highly successful for pome and stone fruits with graft/bud success rate of 86.9% to 95.9%. This was closely followed by wedge grafting (81.5% to 89.1%) and tongue grafting (79.4% to 86.55). In case of walnut, chip budding and wedge grafting during February-March at height of 8-10 cm (83.1%) and 13-15 cm (77.8%) gave higher graft success. T-budding at 8-10 cm height during July-August gave 84.6% to 89.5% success in different temperate fruit crops except walnut. Chip budding, done with active vegetative or dormant mature buds on active vegetative or dormant stocks, respectively, extended the regular budding/grafting season, even if, bud is not slipping in the dormancy period or started stock/scion sap flow in the spring.

Key words: Pome fruit, stone fruit, nut fruit, wedge grafting, chip budding.

Temperate fruit crops namely apple, peach, pear, plum, apricot, almond and walnut occupy major share in North Western Himalayan states of India. However, production and productivity of temperate fruit crops in India was recorded to be lesser in comparison to other major temperate fruit producing countries. Productivity of apple is only 8.1 t/ha in India; whereas, it is above 50.0 t/ha in many countries (NHB, 10 and FAOSTAT, 6). Similarly, it is only 4.5 t/ha and 2.3 t/ha in stone and nut fruits in India, respectively. One of the major causes of low productivity of temperate fruits is associated with the scarcity of quality planting material of superior cultivars. The low rate of multiplication is the major hindrance in meeting the ever increasing demand of planting material. To meet the increasing requirement of quality planting material of different temperate fruit crops, standardization of suitable propagation methods is essential. Existing old and new fruit nurseries are employing traditional grafting and budding techniques for multiplication which is season specific and respond poorly in bud take especially in case of walnut (Ananda *et al*., 2 and Ahmed *et al*., 1). Success of walnut grafting are depended upon grafting/budding technique as well as micro-climatic conditions around the graft union (Sharma and Dar, 11). Chip budding has been reported to be very good for propagation (Gustafson and Morrissey, 7). Considering all these factors, the present experiment was under taken to study the comparative bud take success of various grafting and budding methods as affect by season and bud/graft height.

The experiment was carried out in the experimental fruit nursery, Central Institute of Temperate Horticulture, Mukteshwar, Nainital, India, situated at an altitude of 7000 ft amsl. Average minimum and maximum temperature ranges 2.0-12.9ºC in winter, 5-18ºC in spring, 14-25ºC in summer, 12-22ºC in rainy season and 9-18ºC in fall. Relative humidity was 65-75%. Scion cultivars were collected from apple cv. Starkrimson, pear cv. Bartlett and peach cv. Red June, apricot cv. St. Ambroise, almond cv. Merced and walnut cv. Sulaiman. Rootstocks namely crab apple seedling rootstock '*Parhu*' (*Malus baccata* var. Himalaika) and clonal rootstock M9 for apple, '*Mahel*' (*Pyrus pashia* Kumaonii) seedling for pear, wild peach seedling '*Katero*' (*Prunus persica*) for peach, wild apricot seedling '*Chulli*' (*Prunus americana*) for apricot, Bitter almond (*Prunus amygdalus*) seedlings for almond and Hard shell (*Juglan regia*) seedlings for walnut were used. One year old rootstocks with average diameter of 10 mm in apple, pear, apricot and almond, 11 mm in peach and 13 mm in walnut were selected. In the 1st Experiment (Table 1), chip budding, tongue and wedge grafting were performed in December-January and February-March at rootstock height of 8-10 cm, 13-15 cm and 18-20 cm. In the 2nd experiment (Table 2), chip budding and T-budding were performed during July-August and September-October at same height as in case of grafting. Bench grafting

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Table 1. Treatment combinations of budding/grafting methods, time and height.

Treatment Designation	Grafting/Budding method	Grafting Season	Grafting Height (cm)
T_1	Chip budding	December-January	8-10
T_2	Chip budding	December-January	13-15
T_3	Chip budding	December-January	18-20
T_4	Chip budding	February-March	8-10
T_5	Chip budding	February-March	13-15
T_6	Chip budding	February-March	18-20
T_7	Tongue grafting	December-January	8-10
T_8	Tongue grafting	December-January	13-15
T_9	Tongue grafting	December-January	18-20
T_{10}	Tongue grafting	February-March	8-10
T_{11}	Tongue grafting	February-March	13-15
T_{12}	Tongue grafting	February-March	18-20
T_{13}	Wedge grafting	December-January	8-10
T_{14}	Wedge grafting	December-January	13-15
T_{15}	Wedge grafting	December-January	18-20
T_{16}	Wedge grafting	February-March	8-10
T_{17}	Wedge grafting	February-March	13-15
T_{18}	Wedge grafting	February-March	18-20

Table 2. Treatment combinations of budding methods, time and height.

Treatment Designation	Grafting/Budding method	Grafting Season	Grafting Height (cm)
T_1	Chip budding	July-August	8-10
T_2	Chip budding	July-August	13-15
T_3	Chip budding	July-August	18-20
T_4	Chip budding	September-October	8-10
T_5	Chip budding	September-October	13-15
T_6	Chip budding	September-October	18-20
T_7	T-budding	July-August	8-10
T_8	T-budding	July-August	13-15
T_9	T-budding	July-August	18-20
T_{10}	T-budding	September-October	8-10
T_{11}	T-budding	September-October	13-15
T_{12}	T-budding	September-October	18-20

and bench chip budding was done on dormant rootstocks during winter, whereas, *in-situ* budding was performed during active growth stage during July-October and planted in polyhoused condition where temperature 20-30ºC and RH 70-85% were maintained. Observation was recoded on grafting success, diameter at grafting union and plant height after the end of growing season. The experiment was laid out in factorial RBD with 3 replication consisting 25 plants in each replication. Two years data were analyses using MiniTab 17.

The bud success of chip budding in comparison to tongue and wedge grafting on apple cv. Starkrimson was higher in the month of February-March (Table 1 and Table 3) with success rate of 93.5% and 92.3% at budding height 13-15 cm and 8-10 cm(T_5 and T_4) on rootstock *Malus baccata*. Similarly, 95.9% at budding height 8-10 cm (T_4) and 94.5% at 13-15 cm height bud success was recorded on rootstock M9. However, 85.6% and 87.7% bud success was also recorded at budding height 18-20 cm on the respective rootstocks. The bud success of wedge grafting was 86.0% and

Table 3. Interaction effect of grafting method, time and height on graft success of temperate fruit.

Treatments	Apple		Pear	Peach	Apricot	Almond	Walnut
	Rootstock						
	Malus baccata	M9	*Pyrus pashia*	*Prunus persica*	*Prunus americana*	*Prunus amygdalus*	Hard shell
T_1	61.2	64.2	45.5	42.9	34.8	31.6	21.5
T_2	60.5	65.7	41.2	37.2	33.2	29.9	19.4
T_3	42.5	44.7	39.5	27.7	21.8	21.9	8.5
T_4	92.3	95.9	93.6	94.2	90.4	89.6	83.1
T_5	93.5	94.5	92.5	92.6	84.5	86.9	77.9
T_6	85.6	87.7	83.8	86.1	83.8	77.9	62.1
T_7	39.8	43.2	54.6	42.1	37.9	35.6	41.8
T_8	35.3	36.3	51.9	39.9	35.8	32.3	31.6
T_9	34.7	36.1	43.8	35.8	32.8	23.2	26.4
T_{10}	82.6	86.1	86.5	81.8	82.6	84.7	73.2
T_{11}	78.6	80.5	84.3	79.4	81.6	80.3	68.4
T_{12}	71.4	81.6	74.2	72.3	73.6	68.8	63.6
T_{13}	40.3	45.2	56.9	47.1	43.9	36.9	55.6
T_{14}	37.3	39.6	54.6	44.6	41.8	37	46.6
T_{15}	35.5	36.8	45.5	41.2	34.9	25.5	36.3
T_{16}	86	88.7	87.1	84.2	85.9	89.1	77.8
T_{17}	79.6	78.5	86.9	81.5	82.9	86.9	74.8
T_{18}	76.8	82.3	76.5	74.9	76.2	70.8	61.3
CD(0.05)	8.1	6.9	7.7	7.3	6.9	5.5	6.5

88.7% at 8-10 cm height on the respective rootstocks during the same period. Whereas, tongue grafting recorded 82.6% and 86.1% graft success at 8-10 cm height on the respective rootstocks. Higher rate of chip bud success (Table 1 and Table 3) at height 8-10 cm (T_4) and 13-15 cm (T_5) during February-March was also recorded on pear (93.6% and 92.5%, respectively), peach (94.2% and 92.6%, respectively), apricot (90.4% and 84.5, respectively), almond (89.6% and 86.9%, respectively) and walnut (83.1% and 77.9%, respectively). Success of wedge and tongue grafting on pome, stone and nut fruit crops was above 80% except walnut when performed during February-March at height 8-10 cm as evident in Treatments T_{10} (tongue grafting × February-March × 8-10 cm graft height) and T_{16} (wedge grafting × February-March × 8-10 cm graft height). In case of walnut, tongue grafting gave 73.2% (T_{10}) and wedge grafting gave 77.8% (T_{16}) at height 8-10 cm. Comparative assessment of chip budding with T-budding in experiment 2 (Table 2), revealed that chip budding resulted in higher bud success (Table 4) in all the temperate fruit crops not only in July-August but also in September–October particularly at 8-10 cm (T_1) and 13-15 cm (T_2) budding height, except in case of walnut. The chip budding success during July-August at 8-10 cm height is 93.3% on *Malus baccata* and 94.2% on M9 in apple, 91.7% in pear, 93.1% in peach, 86.9% in apricot and 84.3% in almond. This was followed by treatments T_2 (chip budding × July-August × 13-15 cm height) and T_3 (chip × July-August × 15-20 cm height). On the other hand during September-October (Table 4), chip bud success at height 8-10 cm (T_4) was in the range of 82.2% (almond) to 91.5% (pear). T-budding during July-August at 8-10 cm height gave 84.6% on *Malus baccata* and 87.3% on M9 in apple, 81.4% in pear, 77.2% in peach, 71.4% in apricot and 64.4% in almond. In walnut, chip budding during July-August gave 40.1% success at 8-10 cm height (Table 4). Apart from the grafting or budding methods, season and grafting/budding height was found to be very critical for better success. In case of plant growth parameters as recorded on the plants grafted/ budded (Table 5 and Table 6), it was observed that chip budding during February-March resulted in maximum plant growth (121.9 cm) in comparison to tongue (110.1 cm) or wedge (113.9 cm) grafted plants. During July-August and September-October, chip budded plants recorded height 104.4 cm and 115.4 cm respectively. Similarly, graft/bud union diameter was in the range of 14.1 to 15.1cm when grafted/chip budded during

Table 4. Interaction effect of budding method, time and height on bud success of temperate fruits.

Treatments	Apple		Pear	Peach	Apricot	Almond	Walnut
	Rootstock						
	Malus baccata	M9	*Pyrus pashia*	*Prunus persica*	*Prunus americana*	*Prunus amygdalus*	Hard shell
T_1	93.3	94.2	91.7	93.1	86.9	84.3	40.1
T_2	86.2	88.1	89.6	89.6	83.7	86.9	42.6
T_3	84.3	86.7	84.3	78.9	75.3	75.1	31.7
T_4	87.6	88.8	91.5	90.6	85.9	82.2	21.6
T_5	82.5	85.4	88.6	88	76.8	74.7	20.6
T_6	80.2	83.2	81.4	77.2	71.4	64.4	27.3
T_7	84.6	87.3	85.5	89.5	85.7	87.5	28.2
T_8	77.2	84.5	83.5	86.7	82.6	85.7	16.8
T_9	75.3	77.7	75.7	78.3	74.4	74.9	12.1
T_{10}	69.6	68.4	71.7	76.2	71.3	72.2	18.3
T_{11}	60.3	65.7	66.7	67.7	64.6	64.6	11.3
T_{12}	57.4	62.3	51.8	60.3	52.5	54.1	8.3
CD (0.05)	7.2	6.2	5.6	6.7	5.8	6.4	6.2

Table 5. Interaction effect of grafting and budding methods and time on plant height.

Grafting/Budding method and Time	Apple		Pear	Peach	Apricot	Almond	Walnut	Avg.
	Rootstocks							
	M. baccata	M9	*P. pashia*	*P. persica*	*P. americana*	*P. amygdalus*	Hard shell	
Grafting in different time								
Chip: Dec.-Jan.	114.9	98.4	93.7	96.7	93.6	89.0	59.1	92.2
Chip: Feb.-Mar.	133.6	118.2	131.6	127.7	122.3	116.2	103.4	121.9
Tongue: Dec.-Jan.	108.6	99.5	87.3	84.6	122.4	80.6	83.1	95.1
Tongue: Feb.-Mar.	120.3	100.9	125.9	122.6	81.6	114.2	105.5	110.1
Wedge: Dec.-Jan.	108.0	98.0	92.4	83.3	122.3	88.7	85.7	96.9
Wedge: Feb.-Mar.	120.7	102.9	127.4	117.7	106.2	119.7	102.4	113.9
CD (0.05)	2.6	2.0	1.5	1.5	1.7	3.2	4.3	2.2
Budding in different time								
Chip: Jul.-Aug	107.9	81.8	123.4	116.0	113.4	109.4	79.2	104.4
Chip: Sept.-Oct.	126.1	111.2	133.6	117.5	113.2	114.6	91.6	115.4
T-Bud: Jul.-Aug.	109.0	83.8	122.4	113.6	112.4	110.7	74.8	103.8
T-Bud: Sept.-Oct.	122.0	93.9	115.4	112.3	103.7	118.3	80.0	106.5
CD(0.05)	1.5	3.5	1.34	1.4	1.2	2.6	1.7	1.2

dormant season and 14.7 to 15.4 cm when budded during July-August or September-October (Table 6).

Chip budding has given higher success rate when performed during February-March, July-August and also in September-October in comparison to all the grafting or budding methods, whereas, wedge grafting was found to be highly successful only during February-March. In case of apple on *M. baccata* seedling plants recorded comparatively higher growth than the plants on clonal root stock M 9. The reason may be clonal

Table 6. Interaction effect of grafting and budding method and time on graft/bud union diameter.

Grafting/Budding method and Time	Apple		Pear	Peach	Apricot	Almond	Walnut	*Avg.*
	Rootstocks							
	M. baccata	M9	*P. pashia*	*P. persica*	*P. americana*	*P. amygdalus*	Hard shell	
Grafting in different time								
Chip: Dec.-Jan.	14.0	14.3	14.5	15.2	14.2	14.1	15.6	14.4
Chip: Feb.-Mar.	15.5	15.0	15.2	15.6	14.6	14.6	16.1	15.1
Tongue: Dec.-Jan.	13.1	14.4	14.6	14.9	13.9	13.9	15.5	14.1
Tongue Feb.-Mar.	14.4	14.0	14.3	14.8	13.9	13.8	15.3	14.2
Wedge: Dec.-Jan.	13.5	14.6	14.8	15.1	14.0	13.9	15.8	14.3
Wedge: Feb.-Mar.	14.4	14.1	14.3	14.8	13.8	13.7	15.5	14.2
CD (0.05)	0.03	0.05	0.07	0.15	0.25	0.24	0.30	0.15
Budding in different time								
Chip: Jul.-Aug	14.5	14.7	15.1	15.4	14.4	14.3	16.3	14.7
Chip: Sept.-Oct.	14.8	15.5	15.7	15.9	14.8	14.7	16.7	15.2
T-Bud: Jul.-Aug.	14.2	15.1	15.3	15.6	14.6	14.4	16.4	15.4
T-Bud: Sept.-Oct.	14.4	15.9	16.0	16.1	15.1	15.0	16.9	14.9
CD (0.05)	0.02	0.13	0.20	0.30	0.24	0.41	0.22	0.30

rootstock M 9 is genetically dwarf rootstock. Chip bud contains a triangular wood chip attached to the bud bark which is inserted into the groove on the rootstock. This wood plays a vital role in strong and higher union formation even in dormant season. Thus, chip budding method extends the regular budding/grafting season with active or dormant buds on active or dormant stocks (Gustafson and Morrissey, 7). Chip budding, done with active vegetative or dormant mature buds on active vegetative or dormant stocks, respectively, extended the regular budding/grafting season, even if, bud is not slipping in the dormancy period or started stock/scion sap flow in the spring (Crasweller, 3). Further, chip budding assures better cambial contact and more rapid healing with a complete union of the xylem and the continuous cambial tissues than any other budding techniques like T-budding (Skene *et al*., 12; Gustafson and Morrissey, 7). This is because of the fact that chip bud tissue contains bark and an angular scion wood piece under the bark which tightly fixed into the matching groove made on the rootstock after removing the wood in similar size. The scion chip wood is inserted very closely by matching cambium of the stock. This is not true in case of T-budding, where the cambium layers of the both, scion and stock, are not adjacent and initial union formation can be weak and slow (Howard, 8). Similarly, in case of other grafting method, late winter time grafting gave better success due to favourable environment prevailing at that time for better graft union by callus bridge formation, vascular cambium differentiation across the callus bridge, and secondary xylem and phloem production. Chip budding in apple in the month of mid-February to March gave better result under North Western Himalayan zone in comparison to tongue grafting in March and T-budding in late summer (Ananda, *et al*., 2 and Dimri *et al*., 4). Micro-environmental factors around the walnut grafts have a major impact on callus formation and ultimate graft success, where, temperature and relative humidity 25ºC and 70% during day and 21ºC and 39% during night were found to be optimum for better callus formation, which is not met under open field condition as a result budding or grafting is not highly successful under open environment condition (Sharma and Dar, 11 and Ebrahimi *et al*., 5). Grafting and budding height also effects the linear and radial growth of plant (Kumar and Ananda, 9). Chip budding at height of 8-10 cm and even 13-15 cm during February-March and July-August was highly successful for pome and stone fruits. This was closely followed by wedge and tongue grafting. In case of walnut, chip budding and wedge grafting during February-March at height of 8-10 cm and 13-15 cm gave higher graft success.

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