

Standardization of time of budding and sweet orange cultivars on Carrizo rootstock

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Abstract

In sexual propagation of citrus long juvenility, genetic impurity and self incompatibility are the major problems. Hence the use of suitable rootstock is a pre-requisite in citrus propagation. Now a days, the cultivation of sweet orange is boosting up among citrus cultivation. Due to this, there is a great need for the evaluation of sweet orange cultivars onto an appropriate rootstock. A research trial was carried out in consideration with 'Blood Red', 'Jaffa' and 'Valencia Late' sweet orange cultivars T-budded on Carrizo rootstock at five different intervals of first week of July, August, September, October and February. The treatments were replicated thrice and statistically arranged in factorial randomized complete block design. As a result of the study significant variations were noticed in the performance of cultivars under study at various budding intervals. Out of the sweet orange cultivars 'Blood Red' was the first to initiate sprouting in 28.30 days with healing of bud union in 31.39 days, maximum survival (89.40%), plant height (22.93 cm), number of branches budding⁻¹ (1.14), leaf total nitrogen (1.89%), phosphorus (0.07%) and potassium (1.26%). Among budding intervals, the plants budded on the first week of September were the first to sprout in 26.46 days achieving maximum (23.04 cm) plant height, branches budding⁻¹ (1.15) root formation of (5.98 cm³) volume and survival percentage (91.99). Commercially, 'Blood Red' sweet orange cultivar budded in the first week of September can be cultivated for superior progeny.

Keywords: budding; 'Blood Red'; Carrizo; cultivars; sprouting; survival; sweet orange

Introduction

Citrus cultivation is the most leading of all the fruit crops in tropics and sub-tropics of the world. It is placed under the family Rutaceae and is the largest group consisting of fruits formed of many segments with numerous juicy sacs. Pomologically the fruit of citrus is hesperidium. Although it is a sour fruit but is richly packed with various nutrients especially folic acid, vitamin C, flavonoids, dietary fibers, calcium, potassium and magnesium. Citrus is considered as a boon for the cancer patients due to the presence of chemo-preventive agents in it. They are also very helpful in reducing the constipation, diarrhea and many chronic diseases like arthritis, obesity and coronary heart diseases. Consumption of foods rich in vitamin C improves body immunity against infectious agents and scavenging harmful, pro-inflammatory free radicals from blood. Sweet orange contains a variety of phytochemicals like hesperidin and naringin which has a bio-active effect on human health as an antioxidant, free radical scavenger and immune system modulator (Milind and Chaturvedi, 2012).

Received: 29 Dec 2020. Received in revised form: 23 Apr 2021. Accepted: 07 Jun 2021. Published online: 11 Jun 2021.

From Volume 13, Issue 1, 2021, Notulae Scientia Biologicae journal uses article numbers in place of the traditional method of continuous pagination through the volume. The journal will continue to appear quarterly, as before, with four annual numbers.

It contains low calories but rich in pectin which is considered as a bulk laxative, protects the mucous membrane from exposure to toxic substances as well as by binding to cancer causing chemicals. The plants propagated through seeds are generally self incompatible and genetically impure. Due to these problems, suitable scion and rootstock is necessary for budding sweet orange. In citrus rough lemon rootstock is mostly used for raising the plants but due to its susceptibility to phytophthora it leads to the poor-quality fruits. Due to this the commercial growers are in a great loss (Nasir *et al.*, 2011). In view of these facts the performance of Carrizo rootstock with sweet orange cultivars were undertaken under research study.

Materials and Methods

The research study was conducted at the experimental plot of Horticulture Department, Khalsa College, Amritsar during 2019-2020.

Selection of rootstock

One-year old seedlings of Carrizo which were procured were raised in greenhouse at the Fruit Research Station, Jallowal (Jalandhar). Equal sized, healthy and vigorous seedlings were selected for study.

Selection of scion

Current season shoots of sweet orange cvs. 'Blood Red', 'Jaffa' and 'Valencia Late' were used for collecting scion buds. The scion buds were healthy and disease free. They were collected during first week of February and July-October from college citrus block.

Time of T-budding

The scion buds were T-budded on to the rootstock at five different times (First weeks of February, July, August, September and October respectively). The T-budding operation was completed on same day of the budding.

Execution of budding

The budding was performed by the T-budding method. First a horizontal cut was made on the rootstock at around 10-15 cm above the ground level. Another vertical cut was made from the middle of the horizontal cut (making a T) and the flap of the bark was opened. After making the "T" cut on stock, a boat shaped bud was taken from the scion and fixed in the T-cut flap and was tied with the polythene tape of 200 gauge. Utmost care was taken in the protection of the budded joint against infection. The budded plants were irrigated regularly. Record was taken into consideration days to sprouting, time for healing of bud union(days), plant height(cm), number of branches and leaves budding¹, leaf total nitrogen, phosphorous, potassium and root volume(cm³) were recorded 120 days after budding.

Experimental procedures

Time to sprouting (days)

Time taken in days for initiation of sprouting were counted from the date of budding to the date of first sprouting for each treatment in each replication.

Survival percentage

The number of survived budded plants was counted from all treatments in each replication and then calculated the percentages by following formula:

$$\text{Survival percentage} = \text{number of survived budded plants} / \text{total number of sprouted buds} \times 100$$

Time for healing of bud union (days)

The number of days taken for complete healing of bud union after the date of T-budding was considered as the time for healing of bud union. The results were expressed in number of days.

Plant height (cm)

The data on height of the plant was recorded at 45, 60, 90 and 120 DAB (days after budding). Five plants were selected randomly within each replication. Plant height was measured with scale from the root zone to the top of the plant and was expressed as average per plant in centimeter (cm).

Number of leaves budding¹

Leaves were counted at 45, 60, 90 and up to 120 days after T-budding. All the leaves, irrespective of their size, on the scion shoot were counted and mean number of leaves per plant was calculated and presented in the results.

Leaf area (cm²)

Average leaf area was calculated with the help of leaf area meter by taking 10 fully grown matured leaves in each replication after 120 days of T-budding.

Leaf total nitrogen (%)

The total leaf nitrogen was calculated with Kjeldahl's method and the results obtained were expressed in percentage (Chapman and Parker, 1961).

Leaf total phosphorous (%)

The total leaf phosphorous was determined by vanadomolybdo phosphoric yellow colour method and the results were expressed in percentage (Chapman and Parker, 1961).

Leaf total potassium (%)

The potassium content in leaves was determined by flame photometric method and the results were presented in percentage (Chapman and Parker, 1961).

Root length (cm)

The length of the root was taken with the help of measuring scale at 120 DAB and mean root length of five plants was calculated and expressed in centimeters (Chapman and Parker, 1961).

Root volume (cm³)

The volume of the root was measured by dipping the roots in beaker (water displacement method). It was done in five randomly selected plants from each treatment in each replication 120 days after T-budding and then the average was calculated. The results were expressed in centimeter per cube (Chapman and Parker, 1961).

Statistical analysis

The data recorded for each observed character under the study was subjected to Analysis of Variance (ANOVA) in the Department of Agricultural Statistics, Khalsa College, Amritsar as per the technique of Factorial Randomized Block Design (FRBD) using the software Elementary Designs Analysis (EDA). The critical difference (CD) was used to assess the significance differences between the treatment means.

Results and Discussion

Days to sprouting

The data clearly depicted that out of the cultivars of sweet orange early sprouting was noticed in 'Blood Red' (V₁) accounting (28.30) days while the mean value of 'Valencia late' (V₃) showed a slight variation as compared to V₁ with 29.27 days. Maximum number of days (31.78 days) were noted in 'Jaffa cultivar' (V₂). Less days taken for bud sprouting in the respective cultivar can be attributed to the successful budding union of stock and scion. Also 'Blood Red' species gave maximum sprouting percentage due to which days to sprouting was also reduced. The results of the present study support the findings of Ishfaq *et al.* (2012) and Rehman *et al.* (2017) in sweet orange and Verma *et al.* (2006) in grapes. As compared to the timings T-budding performed under T₃- first week of September sprouted earlier in 26.46 days and budding of first week of February (T₅) took maximum days (32.16 days) to sprout. Earliness in sprouting in the scions budded at different time intervals was observed as time progressed from February to September and then further a delay in sprouting was observed in October. Earliness might be due to the optimum temperature regime for conducting feasible cell activity at the union point which built early vascular connections between xylem and cambium tissue of the scion favouring the scion bud to sprout earlier (Hartmann *et al.*, 2002). The earlier findings of Baloda *et al.* (2016) and Kaur and Kaur (2018) in jamun justify the present results. Among interactions of cultivars and budding intervals earlier sprouting in 24.62 days was noticed in Blood Red plants budded during the first week of September whereas, maximum days (34.13 days) were reported in Jaffa cultivar budded in the first week of February (Figure 1).

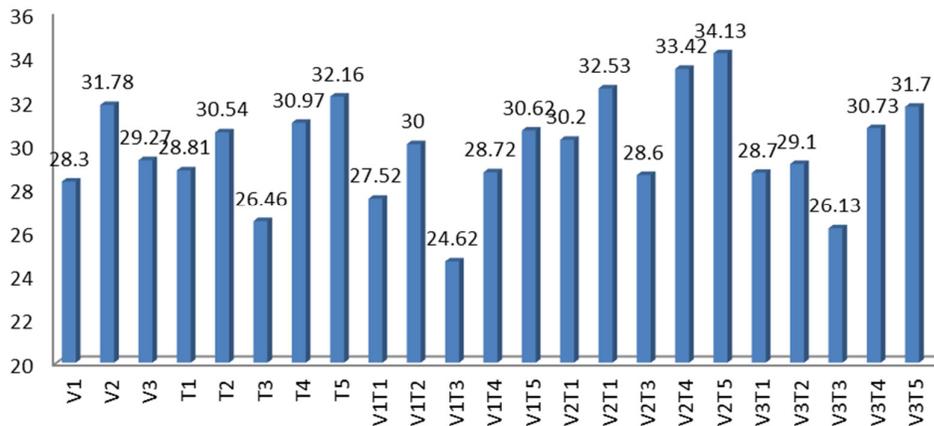


Figure 1. Response of sweet orange cultivars, time of T-budding and interactions on days to sprouting

Survival percentage

The mean data regarding sweet orange cultivars showed that the maximum survival (89.40%) was observed in 'Blood Red' cultivar (V_1) and minimum (83.42%) in cultivar 'Jaffa' (V_2) (Figure 2). The variation observed in survival percentage of different sweet orange cultivars might be due to the fact that the rootstock had a better graft compatibility with certain sweet orange varieties under study (Rehman *et al.*, 2017). Different times of T-budding also had a significant influence on survival percentage. It was observed that budding performed during the first week of September (T_3) had maximum survival percentage (91.99%) with the minimum survival (83.88%) observed when budding was done during first week of August (T_1). The prevailing environmental conditions might be responsible for survival. The availability of sufficient sap from the scion and stock might have rapidly healed the bud union. Due to this the swollen bud acquired better growth. The findings of Gotur *et al.* (2017) in guava, Baloda *et al.* (2016) and Mahore (2014) jamun advocates the present findings. The interactive effect of cultivars and budding intervals registered maximum survival (94.57%) in 'Blood Red' cultivar budded in the first week of September (V_1T_3) while the minimum survival 79.53 percentage was recorded when 'Jaffa' cultivar was budded during first week of August (V_2T_1) (Figure 3).

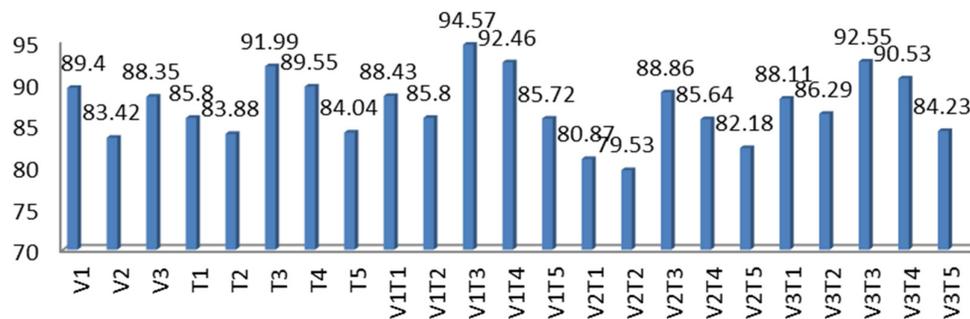


Figure 2. Response of different sweet orange cultivars, time of T-budding and interactions on survival percentage

Time for healing of bud union (days)

The data depicted that the time for healing of bud union was minimum (31.39 days) in 'Blood Red' cultivar (V_1) where as it was maximum in Jaffa cultivar of sweet orange (V_2) generating 34.56 days (Figure 4). Different times of T-budding operation also had a significant influence on the time for healing of bud union. It was observed that minimum time (29.14 days) for healing was taken when budding was done in the first week of September (T_3) and the maximum time of 35.77 days was recorded when budding operation was performed during first week of February (T_5). Regarding the combined effect of cultivars and budding time 'Blood Red' cultivar budded during first week of September (V_1T_3) healed earlier in 8.26 days while the maximum time (35.83) days for healing of graft union was recorded when 'Jaffa' cultivar was budded during first week of February (V_2T_5). The minimum time required by the combination V_1T_3 ('Blood Red' during first week of September) might have resulted from a closure alignment of cambial layer in stock and scion during that time which is conducive for the rapid formation of the bud union (Thokchom *et al.*, 2019) (Figure 5).



Figure 3. Survival of plants budded during first week of September at 120 days after budding in sweet orange cultivar (a) 'Blood Red' (b) 'Jaffa' (c) 'Valencia Late'



Figure 4. A view of healed bud union of sweet orange cv. 'Blood Red'

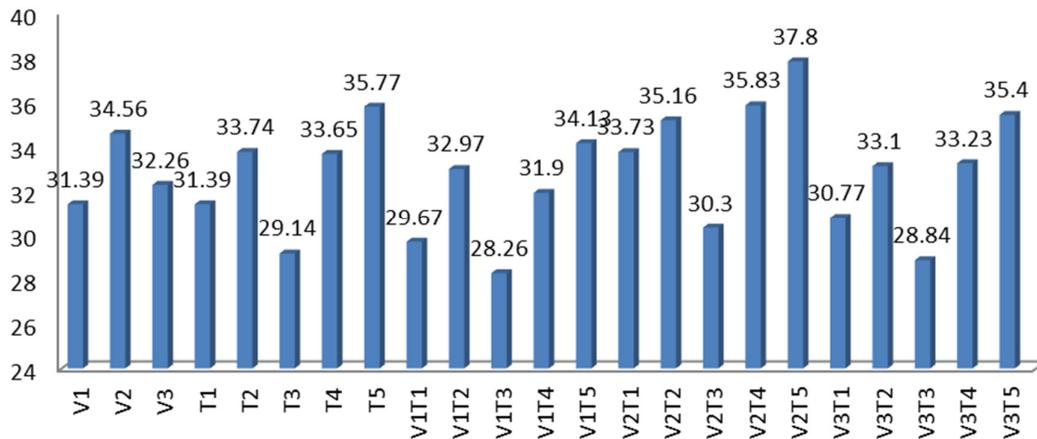


Figure 5. Response of different sweet orange cultivars, time of T-budding and interactions on time for healing of bud union

Plant height (cm)

From the results it has been found that 'Blood Red' (V₁) produced plants with significantly maximum height (22.93 cm) after 120 days of budding and the minimum (20.16 cm) plant height in V₂ was recorded effectively throughout the growing period. An increase in plant height might be attributed to the vigorous character of scion. Another reason for the greater height of plants might be that the bud sprouted earlier received a fairly long period of favorable weather for vegetative growth (Singh, 2007). It was evident from the results obtained by Ahmed *et al.* (2013) that the cultivar and rootstock combination affected the plant height. Among different times of T-budding the first week of September (T₃) budded plants were (23.04 cm) long and when budding was practiced during first week of August (T₂) the plants remained at the lowest height (21.11 cm) at 120 DAB. The research trial carried out by Patel *et al.* (2007) wherein they observed that plant height was influenced by date of propagation. The higher content of auxins in the plants (Hartmann *et al.*, 2007) was also responsible for plant height. A perusal of data revealed that the interactions between sweet orange cultivars and time of T-budding were found to be non significant at the early stages but the results after 60 DAB showed significant results with maximum plant height (24.75 cm) in sweet orange cv. Blood Red cultivar budded in

first week of September- V_1T_3 which was statistically superior over all the other treatment combinations, whereas minimum plant height (19.23 cm) was noted down in Jaffa cultivar when budding was performed during first week of February (V_2T_5). However, the lowest height was observed in V_2T_5 measuring 15.26 cm.

Number of branches budding¹

It is evident from the data that maximum number of branches were produced in 'Blood Red' cultivar (V_1) accounting to 1.14 at 120 DAB where as they were found to be minimum (1.02) at 120 DAB in 'Jaffa' cultivar (V_2). The reason might be due to the maximum quantity of leaves budding¹ and longest shoot length recorded in the citrus species. These results are in close agreement to the findings of Khattak (1990) who recorded significant variation in the branch quantity of the citrus varieties propagated by budding. Rehman *et al.* (2017) also reported the same in sweet orange. Among different times all the intervals registered slight variations. In the results maximum number of branches (1.15) were obtained in first week of September (T_3) budded plants whereas the minimum (1.02) branches were obtained when budding was performed during first week of August (T_2) after 120 DAB. This might be due to the good vegetative growth of the budding as a result of favourable environmental conditions leading to an increase in number of branches of budding. It corresponds to the findings of Khan *et al.* (2018) wherein it was observed that time of propagation had a significant effect on number of branches budding¹. It is evident from the tables that non significant interactions were noticed between the sweet orange cultivars and time of T-budding.

Leaf number budding¹

Maximum leaves (21.62) were registered in 'Blood Red' cultivar (V_1) while the minimum leaves (18.26) were observed in cultivar 'Jaffa' at 120 DAB. It might be due to the maximum budding girth and compatibility of these two species. The healthier buddings resulted in maximum number of leaves (Rehman *et al.*, 2017). Similar results were found by Rehman and Rab (2012) wherein the analysis of variance showed that cultivar and rootstock combination had a significant effect on the number of leaves per budding. Pomper *et al.* (2009) also viewed that different scion cultivars have an efficient influence on number of leaves of sweet orange cultivars. The data about different timings of T-budding also showed significant effects on the number of leaves. Among different times of budding, first week of September (T_3) was found to be statistically superior in increasing the number of leaves to the tune of 21.64 and minimum number of leaves (18.84) were produced per budding budded during first week of August (T_2). Increment in leaves can be due to good growth in linear and radial plant growth as an effect of the adaptable atmospheric conditions leading to instant dividing cells (Chauhan, 2000). Also, the cell activity and better healing of graft union during these months have increased leaf formation. The findings align with Singh *et al.* (2004) in citrus. Interactive effect of cultivars and propagation significantly influenced the leaf number being the maximum number of leaves (22.86) were recorded in treatment combination V_1T_3 and V_3T_4 being minimum (22.40) at 120 DAB.

Leaf total nitrogen (%)

The data furnished clearly depicted that sweet orange cultivars and time of T-budding along with their interaction had significant influence over the total leaf nitrogen. Among the sweet orange cultivars 'Blood Red' (V_1) showed maximum leaf total nitrogen (1.89%) content while the mean value of 'Valencia Late' (V_3) showed a slight variation as compared to V_1 with 1.81%. Minimum leaf nitrogen (1.54%) was noted in 'Jaffa' cultivar (V_2) analysed 120 DAB. It might be due to the reason that the scion influences the root system of the rootstock which in turn influences the nutrient uptake by the plants (Goswami, 2017). Toplu *et al.* (2008) also stated that the highest total N concentration was observed in scion leaves of 'Valencia Late' variety on Carrizo. The results are also in correspondence with the findings of Perez-Zamora (2004) and Jahromi *et al.* (2012). As compared to the budding period the first week of September (T_3) resulted in maximum leaf total nitrogen (1.96%) followed by T_4 with 1.84% leaf total nitrogen. The leaf total nitrogen in T_1 and T_2 showed slight variations while budding performed in first week of February (T_5) resulted in minimum total leaf nitrogen

(1.58%) 120 DAB. The content of nitrogen (2.15%) was maximum from the 'Blood Red' plants when they were budded in the first week of September and was minimum (1.43%) when 'Jaffa' cultivar was budded in first week of February which was at par with the leaf total nitrogen recorded in plants budded with Jaffa cultivar during first week of August (1.44%) and July (1.48%) (Figure 6).

Leaf total phosphorous (%)

It was evident from the data that non significant influence on the leaf total phosphorus in various stionic combinations was recorded after 120 days of budding. However, among various cultivars and times of T-budding V₁ and T₃ showed a comparatively higher leaf total phosphorus i.e. 0.07 % and 0.08 % respectively while among various treatment combinations, the highest leaf total phosphorus i.e. 0.09% was observed in V₁T₃, V₁T₄ and V₃T₃ and minimum (0.02 %) was observed in V₂T₅ treatment (Figure 6).

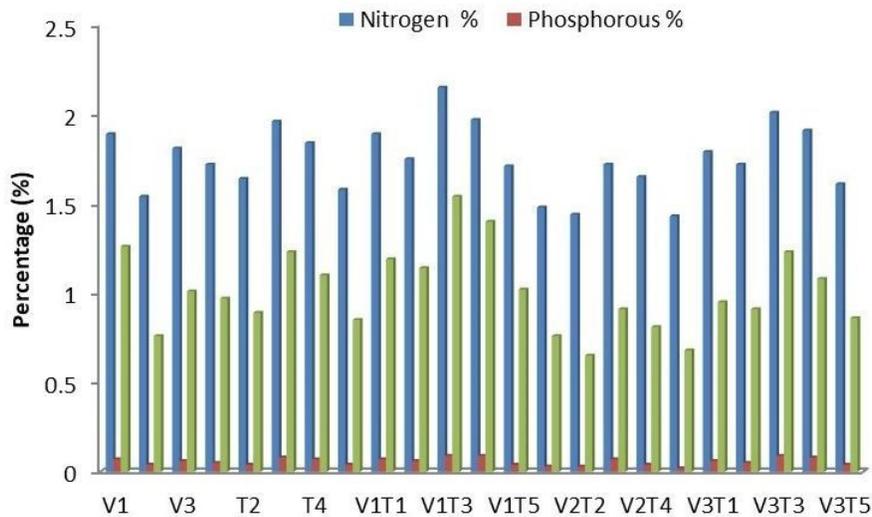


Figure 6. Response of sweet orange cultivars, time of T-budding and interactions on plant nutrient status

Leaf total potassium (%)

The data presented in Table 2 clearly depicted that sweet orange cultivars and time of T-budding along with their interaction had significant influence over the total leaf potassium. It is evident from the data that 'Blood Red' (V₁) resulted in maximum leaf total potassium (1.26%) while the mean value of 'Valencia Late' (V₃) showed a slight variation as compared to V₁ with 1.01%. Minimum leaf potassium (0.76%) was noted in 'Jaffa'. Sau *et al.* (2018) also stated that the highest total K concentration was observed in scion leaves of Nagpur mandarin on Karna Khatta. Jahromi *et al.* (2012) also confirmed the same. As compared to the budding the first week of September (T₃) resulted in maximum leaf total potassium (1.23%) followed by T₄ with 1.10% leaf total potassium. The leaf total potassium in T₁ and T₂ showed slight variations while budding performed in first week of February (T₅) resulted in minimum total leaf potassium (0.85%). Regarding interactions maximum potassium (1.54%) was in 'Blood Red' when budded on the first week of September.

Table 1. Effect of sweet orange cultivars and time of budding on sprouting and budding vigour

Factor A (Cultivars)	Days to sprouting	Time for healing bud union (days)	Survival (%)	Plant height (cm)	Number of branches plant ⁻¹
V1	28.30	31.39	89.40	22.93	1.14
V2	31.78	34.56	83.42	20.16	1.02
V3	29.27	32.26	88.35	22.22	1.07
CD (p=0.05)	0.30	0.31	0.30	0.17	0.03
Factor B (Time)					
T1	28.81	31.39	85.80	21.22	1.09
T2	30.54	33.74	83.88	20.65	1.02
T3	26.46	29.14	91.99	23.04	1.15
T4	30.97	33.65	89.55	22.84	1.09
T5	32.16	35.77	84.04	21.11	1.03
CD (p=0.05)	0.39	0.39	0.39	0.23	0.04
Interaction (A x B)					
V1T1	27.52	29.67	88.43	22.30	1.15
V1T2	30	32.97	85.80	21.40	1.07
V1T3	24.62	28.26	94.57	24.75	1.25
V1T4	28.72	31.90	92.46	24.09	1.20
V1T5	30.62	34.13	85.72	22.15	1.07
V2T1	30.2	33.73	80.87	19.68	1.03
V2T2	32.53	35.16	79.53	19.53	0.97
V2T3	28.6	30.30	88.86	21.45	1.07
V2T4	33.42	35.83	85.64	20.91	1.01
V2T5	34.13	37.80	82.18	19.23	1.01
V3T1	28.7	30.77	88.11	21.70	1.11
V3T2	29.1	33.10	86.29	21.01	1.02
V3T3	26.13	28.84	92.55	22.93	1.15
V3T4	30.73	33.23	90.53	23.51	1.07
V3T5	31.7	35.40	84.23	21.94	1.02
CD (p=0.05)	0.67	0.69	0.69	0.40	NS

V₁ = Blood red, V₂ = Jaffa, V₃ = Valencia late T₁ = First week of July, T₂ = First week of August, T₃ = First week of September, T₄ = First week of October, T₅ = First week of February

Root volume (cm³)

Under the research study the sweet orange cultivars and time of T-budding on root volume was studied at 120 days after budding and results so obtained are depicted in Table 2. Results of the study showed that root volume varied significantly in different sweet orange cultivars. The maximum root volume (6.50 cm³) was given by the 'Blood Red'/Carrizo combination which was followed by cultivar 'Valencia Late' with (5.23 cm³) and the minimum root volume (4.52 cm³) was observed in the plants budded with 'Jaffa' cultivar (V₂). The increased volume of rootstock might be improved by the soil growth of plants of sweet orange varieties. The reason might also be the better stock-scion compatibility used in the study. Similar results had been stated by Girardi and Filho (2006) who worked on different sweet orange varieties and found significant effect on root growth and volume of the plants. The data about different times of budding also showed significant influence on root volume. Maximum root volume (5.98 cm³) was observed when budding operation was performed in the first week of September which was at par with budding operation performed during first week of October with 5.85 cm³ and the minimum root volume (4.67 cm³) was recorded in the plants budded during the first week of July (T₁). Interactions between cultivars and time of budding also significantly influenced the root volume. Roots with maximum volume (7.15 cm³) were produced in V₁T₃ treatment combination while the minimum root volume (3.52 cm³) was recorded in the treatment combination of V₂T₁.

Table 2. Effect of sweet orange cultivars and time of budding on budding leaf and root parameters

Factor A (Cultivars)	Number of leaves	Leaf total nitrogen (%)	Leaf total phosphorous (%)	Leaf total potassium (%)	Root volume (cm ³)
V1	21.62	1.89	0.07	1.26	6.50
V2	18.26	1.54	0.04	0.76	4.52
V3	21.59	1.81	0.06	1.01	5.23
CD (p=0.05)	0.21	0.02	NS	0.02	0.18
Factor B (Time)					
T1	19.94	1.72	0.05	0.97	4.67
T2	18.84	1.64	0.04	0.89	5.02
T3	21.64	1.96	0.08	1.23	5.98
T4	21.09	1.84	0.07	1.10	5.85
T5	20.94	1.58	0.04	0.85	5.55
CD (p=0.05)	0.28	0.03	NS	0.03	0.24
Interaction (A x B)					
V1T1	21.40	1.89	0.07	1.19	5.92
V1T2	19.39	1.75	0.06	1.14	6.38
V1T3	22.86	2.15	0.09	1.54	7.15
V1T4	22.78	1.97	0.09	1.40	6.92
V1T5	21.54	1.71	0.04	1.02	6.12
V2T1	17.50	1.48	0.03	0.76	3.52
V2T2	17.06	1.44	0.03	0.65	3.87
V2T3	19.56	1.72	0.07	0.91	5.03
V2T4	18.01	1.65	0.04	0.81	5.21
V2T5	19.08	1.43	0.02	0.68	4.97
V3T1	20.91	1.79	0.06	0.95	4.59
V3T2	20.09	1.72	0.05	0.91	4.81
V3T3	22.49	2.01	0.09	1.23	5.76
V3T4	22.40	1.91	0.08	1.08	5.41
V3T5	22.22	1.61	0.04	0.86	5.26
CD (p=0.05)	0.49	0.05	NS	0.05	0.41

V₁ = Blood red, V₂ = Jaffa, V₃ = Valencia late T₁ = First week of July, T₂ = First week of August, T₃ = First week of September, T₄ = First week of October, T₅ = First week of February

Conclusions

As an outcome of the research study T- budding of sweet orange cultivar 'Blood Red' on Carrizo rootstock in the first week of September was successful than other cultivars under the agro-climatic conditions of Punjab in terms of budding success and vegetative growth of the buddings so formed. This will ensure better germplasm for successful cultivation of sweet orange leading to a good income to the commercial fruit growers.

Authors' Contributions

Conceptualization of research work and designing of experiment (AJK); Execution of field/lab experiments and data collection (FDS); Analysis of data and interpretation (FDS and AJK); Preparation of manuscript (AJK). Both authors read and approved the final manuscript.

Acknowledgements

Heartiest thanks to Khalsa College Charitable Society for supporting the research.

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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