International Journal of Environmental & Agriculture Research (IJOEAR)
ISSN: [2454-1850]
[Vol-12, Issue-2, February- 2026]
Website: www.ijoear.com
Journal DOI: 10.25125/agriculture-journal

Effect of Different Times and Methods of Budding in Apricot (*Prunus armeniaca* L.) using Seedling Rootstock of Peach

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Received:- 09 February 2026/ Revised:- 18 February 2026/ Accepted:- 23 February 2026/ Published: 28-02-2026
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Abstract— *The present investigation on effect of different times and methods of budding in apricot (Prunus armeniaca L.) using seedling rootstock of peach was conducted under field conditions at the Fruit Nursery and Department of Fruit Science, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand, during 2019. The experiment consisted of twenty-four treatment combinations which were replicated thrice in Factorial Randomized Complete Block Design. Apricot cv. Newcastle was budded at 15-day intervals from 15th July to 30th September using four budding methods: T-budding, Patch budding, Chip budding, and Ring budding. Observations were recorded on days to sprouting, sprout length, sprout diameter, number of branches, number of leaves, leaf area, dead plants after sprouting, dead plants without sprouting, survival percentage, and saleable plant percentage. Earliest bud sprout (78.588 days), maximum sprout length (48.25 cm), thickest sprout diameter (0.878 cm), highest number of branches (25.333), maximum number of leaves (115.7), and highest survival percentage (71.25%) were observed for plants budded on 15th July. Among methods, chip budding resulted in earliest sprouting (135.3 days) and highest survival (67.9%), while T-budding produced longer shoots (29.8 cm) and better saleable plants (79.7%). The combination of 15th July with chip budding (T1M3) performed best across most parameters with earliest sprouting (70 days), longest sprouts (53.3 cm), thickest sprouts (0.95 cm), highest branches (27.3), most leaves (129), highest survival (85.0%), and highest saleable plants (91.7%). Budding in late September resulted in poor performance across all parameters. The study concludes that mid-July budding with chip budding is most suitable for apricot propagation on peach rootstock under Garhwal Himalayan conditions*.

Keywords— Budding, Peach seedling rootstock, Time of budding, Method of budding, Sprout length, Bud take success, Apricot propagation.

I. INTRODUCTION

Apricot (*Prunus armeniaca* L.) belongs to family Rosaceae and is mostly grown in the temperate regions of the world i.e., Western and Central Asia, Europe, North Western Himalaya and Western Tibet. In origin it is said to be native to China and in India it is mostly grown in Jammu and Kashmir, Himachal Pradesh, and Uttarakhand and to a limited extent in the Nilgiries with an annual production of 24.94 lakh metric tonnes from an area of 3.38 lakh ha (Sheikh et al., 2021). In Uttarakhand, it occupies total area of 8065.02 hectare with an annual production of 28026.62 metric tonnes (Anonymous, 2019). Almora district has maximum area and production of apricot with some cultivars like Shakarpara, Nugget, and Ladakhi etc. which have better fruit quality and are grown in higher hills (Naithani et al., 2018). New Castle is the most commercially accepted cultivar of apricot for the mid hills area of Uttarakhand (Sharma et al., 2014). It is a mid-season cultivar orange-yellow in colour and

has good demand for both table and processing purpose (Pawar et al., 2023). It ripens towards the end of May (Prakash et al., 2020). Apricots are enjoyed as fresh fruit, but also used for preparation of different value-added products due to their perishable nature. Mesocarp of the fruit is edible while endocarp (stone) remained waste. However, seed kernels are enclosed in stone. These apricot kernels are valuable sources of lipid and basically processed for their edible oils (Pawar et al., 2023).

Propagation of apricot by seed is not recommended because seeds are produced by cross fertilization and result in undesirable trait combinations. Seedlings grown from cross between commercial fruiting varieties contain a mix of parental genetic backgrounds and they are not identical to their parents and also differ in growth and fruiting habit (Bourguiba et al., 2012). This variability is desirable for plant breeding in development of new varieties but it is not desirable for uniform growth in orchard establishment (McKey et al., 2010). Apricot and other stone fruits tend to have a poor root system that is susceptible to pests, pathogens and environmental stress, so that stone fruits are propagated by budding or cutting techniques and grown on rootstock varieties (Hartmann et al., 2002). Stone fruits such as apricot, plum, peaches and nectarines are budded from late July to September for retail nurseries because trees produce a larger caliper (Hussain et al., 2018). The present study was therefore conducted to determine the suitable time of budding and to identify the best budding method for apricot propagation on peach seedling rootstock under the hilly conditions of Garhwal Himalaya.

II. MATERIALS AND METHODS

The present investigation entitled "Effect of different times and methods of budding in apricot (*Prunus armeniaca* L.) using seedling rootstock of peach" was conducted under open field conditions at the Fruit Nursery, Department of Fruit Science, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand, India, during the year 2019-20. Apricot variety "Newcastle" was budded at 15-day intervals on peach seedling rootstock, from 15th July up to 30th September with T-budding, Chip budding, Patch budding and Ring budding methods.

The experiment was laid out in Factorial Randomized Complete Block Design with twenty-four treatment combinations replicated thrice. The following parameters were studied:

Days taken to first bud sprouting (number of days): The number of days required for sprouting of buds (from the date of budding) was recorded treatment-wise for each plant of apricot.

Length of sprouted shoots of budded plants (cm): The length of sprouted shoots of budded plants was measured with the help of scale in centimetre at 30 days intervals after initiation, for each plant separately and average length of sprouted shoots per plant was calculated. These observations were recorded up to final survival of budding and average was worked out.

Diameter of sprout (cm): The diameter of randomly selected sprout was measured in centimetre with the help of screw gauge at 30 days interval and average was worked out.

Number of branches per bud sprout: The number of branches was counted treatment-wise for each plant and average number per plant was calculated.

Number of leaves per bud sprout: The total number of leaves was counted on newly emerged shoots of buds at 30 days interval and average number of leaves on sprouted buds was calculated.

Total leaf area (cm^2): The leaf area was recorded by means of a digital leaf area meter. Firstly, ten leaves were selected randomly from each of the tagged budded plants and their average leaf area was calculated and multiplied with average number of leaves per plant to obtain the total leaf area.

Dead budded plants without sprouting (%): The percent of dead budded plants was recorded in each treatment at 270 days after budding. It was calculated with the help of following formula:

$$\text{Dead budded plants without sprouting (\%)} = \frac{\text{Number of dead budded plants}}{\text{Total budded plants}} \times 100 \quad (1)$$

Dead budded plants after sprouting (%): The percent of dead budded plants after sprouting observed in each treatment at 270 days after budding was calculated with the help of following formula:

$$\text{Dead budded plants after sprouting (\%)} = \frac{\text{Number of dead budded plants after sprouting}}{\text{Total budded plants}} \times 100 \quad (2)$$

Total survival of budded plants (%): The survival of budded plants was recorded in each treatment after 8 to 10 months at the termination of experiment and the survival percentage of buds was calculated by following formula:

$$\text{Total survive plants (\%)} = \frac{\text{Number of survive budded plants}}{\text{Total budded plants}} \times 100 \quad (3)$$

Total saleable plants (%): The plants attaining good height and vigour in growth were considered as saleable plants. The number of such saleable plants was recorded at the end of growing season and expressed as:

$$\text{Total saleable plants (\%)} = \frac{\text{Number of saleable plants}}{\text{Total survived plants}} \times 100 \quad (4)$$

Data were analyzed using appropriate statistical software and means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

III. RESULTS AND DISCUSSION

3.1 Days Taken to Bud Sprouting:

The data presented in Table 1 show that the earliest bud sprout (77.8 days) was observed when budding was practiced on 30th July (T2 treatment). This may be due to favorable environmental conditions. While the maximum time (181.7 days) was taken by plants budded at the end of September (T6). Among various methods of budding, chip budding (M3) ranked first in bud burst which took only 135.3 days to sprout. Good sap flow in the bark and high temperature might be the factors which favoured callusing and proliferation at the bud union. Maximum days taken to bud sprout (148.5 days) were recorded in Ring budding (M4). The interaction among days to sprout showed significant effect for different times and methods. Among all treatment combinations, T1M3 (15th July with chip budding) showed the earliest bud sprout (70.0 days). This may be due to maximum sap flow in rainy season creating suitable conditions for this time and method of budding. The maximum days taken to bud sprout (189.0 days) was recorded in ring budding at the end of September (T6M4). In accordance with our present investigation, Ahmad et al. (2012) observed significant effect of budding method and time on number of days to sprouting, showing that maximum number of days to sprouting (199.14) were observed in plants produced through T-budding in September while minimum number of days to sprouting (194.29) were recorded for chip budding in August in guava.

3.2 Average Length of Longest Bud Sprout (cm):

Data presented in Table 1 show that the maximum average length of longest bud sprout (48.25 cm) was recorded under T1 (15th July). The reason is that the bud sprout resulting from budding during the growth season had a longer time available for its growth, while the minimum length of shoot (20.58 cm) was observed in T6 (30th September). T-budding (M1) gave maximum length of bud sprout (29.8 cm). However, the minimum shoot length (25.2 cm) was found in treatment M4 (ring budding). The interactions among different times and methods of budding were also found significant with respect to the longest bud sprout. Maximum sprout length (53.3 cm) was obtained when chip budding was practiced on 15th July (T1M3 treatment combination). Whereas, minimum (16.3 cm) was recorded in treatment combination T6M4 (30th September + ring budding). These results confirm the findings of Yazdani et al. (2015) who indicated that shoot length was obtained from black sweet cherry scion with T-budding performed at 10-12 cm above ground.

3.3 Diameter of Thickest Sprout (cm):

Data presented in Table 1 show that budding on 15th July (T1 treatment) recorded the thickest sprout with a diameter of 0.878 cm. The obtained results could be related to high precipitation and high summer temperatures during July which created good conditions for bud growth and development of the stem. Whereas, minimum diameter of sprout (0.716 cm) was observed in T6 (30th September). When different methods of budding were practiced, the maximum average diameter (0.778 cm) was recorded with T-budding (M1 treatment). This may be due to early and good wound tissue formation on cut surfaces and rapid cambial connectivity between stock and bud. Whereas M4 (ring budding) recorded minimum average diameter (0.756 cm).

Budding on 15th July with chip budding (T1M3 treatment combination) was found to give maximum average diameter of thickest sprout (0.95 cm). It is clear from the mean data that plants budded through chip budding had maximum bud growth which results in maximum stem thickness due to more photosynthetic activity. While the minimum diameter of sprout (0.69 cm) was recorded in the treatment combination T6M1 (30th September + T-budding). Ananda et al. (1999) reported that statistical analysis of the data revealed that budding dates, methods and their interaction had significant effect on stem thickness in peach budding. Maximum stem thickness (1.905 cm) was recorded on plants budded on Peshawar local rootstock of peach.

3.4 Number of Branches per Budded Plant:

Data presented in Table 1 show that T1 treatment (15th July) resulted in maximum average number of branches per budded plant (25.333). This might be due to long growing period and active vegetative growth of plants at this time. However, the minimum number of branches per budded plant (15.5) were found in T6 (30th September). Among different methods, Patch budding (M2 treatment) gave maximum average number of branches per sprout (22.5). The highest number of branches might be due to the quick union formation under patch budded plants resulting in the best performance of vegetative characters. The minimum average number of branches per budded plant (18.1) was recorded in M4 (ring budding). The interaction among different times and methods found that the maximum number of branches (27.3) was recorded under T1M3 treatment combination (15th July with chip budding). The better number of branches with optimum time and methods might be due to better bud growth which augmented absorption and translocation of nutrients from soil, taking active part in various plant metabolic processes (Singh, 2001). The minimum number of branches per budded plant (11.3) was recorded in the treatment combination T6M4 (30th September + ring budding). The results are in parallel with Janesari and Jafarpour (2015) who budded apricot scion on plum rootstock and found that August may be the most appropriate time of budding with significant effect on the average maximum number of branches (61.0).

3.5 Number of Leaves:

Data presented in Table 1 show that the number of leaves on budded plants (115.7) was maximum under T1 treatment (15th July). This may be due to increased growth of plants resulting in a greater number of leaves, long growth season and active growth period. However, the minimum number of leaves (30.6) was found in treatment T6 (30th September). When different methods of budding were practiced, the maximum number of leaves on budded plants (70.5) was recorded from T-budding (M1 treatment). This may be due to wood maturity of budwood which probably reserves high starch and sugar, while the lowest number of leaves (59.4) were recorded in M4 (ring budding). The interactions among different times and methods of budding were also found significant with respect to the number of leaves. The 15th July with chip budding (T1M3 treatment combination) was found to give maximum number of leaves on new sprouts (129). The higher number of leaves with optimum time and methods might be due to better bud growth and more number of branches. Ring budding practiced on 30th September (T6M4) gave minimum (29.7) average number of leaves. This augmented absorption and translocation of nutrients from soil which take active part in various plant metabolic processes. These results matched the findings of Akhtar et al. (2000) who observed that maximum number of leaves (292.546) occurred on peach plants budded on 28th August with chip budding, which may be due to maximum number of branches and maximum bud growth.

3.6 Leaf Area (cm^2):

The data recorded in Table 1 for leaf area (26.20 cm^2) was found highest when budding was done on 15th July (T1 treatment). It is due to vigorous growth of plant as it is capable of absorbing more nutrients and preparing more photosynthates resulting in maximum leaf area. However, the minimum leaf area (23.07 cm^2) was recorded in T4 (30th August). Among various methods of budding practiced, the maximum leaf area (29.42 cm^2) was recorded under patch budding (M2 treatment). It is due to stronger bud union and development of normal vascular tissues at the bud union which regulates the transport of water and nutrients, thereby increasing the leaf area. Whereas M4 (ring budding) recorded minimum leaf area (26.17 cm^2). The interactions among different times and methods of budding were also found significant with respect to leaf area. Chip budding on 15th July (T1M3 treatment combination) was found to give maximum leaf area (28.5 cm^2). It might be due to the fact that chip budded plants had early sprouting under this time, leaf emergence and rapid vegetative growth as compared to T, patch

and ring budded plants. However, the minimum leaf area (16.4 cm^2) was observed in T6M4 (30th September + ring budding). The results are in parallel with Kumar and Ananda (2004) who reported in apple that leaf area was maximum with chip budding in August, and leaf area is directly related to the maximum number of leaves.

3.7 Dead Budded Plants without Sprouting (%):

Data recorded in Table 1 show that the percentage of dead budded plants without sprouting (14.08%) was lowest under T1 treatment (15th July) and T2 treatment (30th July). This may be due to favorable climatic conditions for bud growth, while high temperature also inhibits bud bursting and causes even death of buds. However, the maximum dead plants (25.67%) were found in treatment T6 (30th September). Among various methods of budding practiced, the minimum percentage of dead budded plants was recorded in M2 (16.4%) and M3 (16.2%). This may be due to proper cambium formation with translocation of food material through xylem and phloem from stock to bud. The highest dead plants (17.7%) were recorded from M1 and M4 (T-budding and ring budding). The interaction between different times and methods of budding showed that the minimum percentage of dead budded plants (8.3%) was produced by T1M3 (15th July with chip budding). Poor shooting of the buds planted during cooler time of the season may be due to the fact that these buds might have been carrying higher inhibitors or it may be due to higher nitrogen to carbohydrate ratio. Maximum percent of dead budded plants (31.3%) was recorded in T6M4 (30th September + ring budding).

3.8 Dead Budded Plants after Sprouting (%):

Data presented in Table 1 show that the dead budded plants after sprouting (14.58%) were minimum under 15th July (T1 treatment). This may be due to favorable conditions for continued growth. However, the maximum dead plants (22.75%) were found in treatment T6 (30th September). Among various methods of budding, the minimum dead budded plants (12.11%) were recorded under M2 treatment (patch budding). This may be due to proper translocation of carbohydrates, starch and other factors. The highest dead plants (18.78%) were recorded in M4 (ring budding). The interactions among different times and methods of budding were also found significant. It is evident from the data that the minimum percentage of dead budded plants after sprouting (6.7%) was produced by T1M3 (15th July with chip budding). Poor shoot formation during this season may be due to higher nitrogen to carbohydrate ratio. Treatment combination T6M4 (30th September + ring budding) recorded the highest dead plants after sprout (43.3%).

3.9 Survival of Budded Plants (%):

Data presented in Table 1 show that the maximum survival percentage (71.25%) was obtained with 15th July (T1 treatment). This may be affected by season and several factors such as temperature, light and nutrient availability. Minimum survival percent (40.08%) was recorded in T6 (30th September). Among different methods, chip budding (M3 treatment) gave maximum survival percentage (67.9%). This may be due to requiring more cell sap for union and thus scion is held more tightly in place as compared to patch budding. Minimum survival percent (53.9%) was recorded from the treatment M4 (ring budding). The interaction between different times and methods had significant effect on survival percentage. The plants budded on 15th July had the maximum survival percentage (85.0%) with chip budding (T1M3 treatment combination), while minimum was recorded (16.3%) in T5M4 (15th September + ring budding). It is due to the fact that budding in July produces favorable environmental conditions for the healing process of bud wounds and results in the development of normal vascular tissues at the bud union, which results in maximum plant survival. Similarly, budding late in the growing season contributed to unfavorable conditions for healing process which results in poor development of normal vascular tissue at the bud union. The findings of the study conducted by Negi et al. (2010) observed in case of propagation methods (patch budding) of Aonla gave better survival of budded plants (80.333%).

3.10 Total Saleable Plants (%):

Data recorded in Table 1 show that the plants budded on 30th July (T2 treatment) gave maximum saleable plants (81.25%). It is due to longer period of time available for growth. Whereas the minimum saleable plants percent (62.67%) was recorded in T6 (30th September). Among different methods, patch budding (M2 treatment) gave maximum saleable plants (76.7%). It is

due to these plants requiring heading back for quality and good health growth in the next year. Minimum saleable percent (67.3%) was recorded from the treatment M4 (ring budding). Interaction among different times and methods had significant effect. The best result was obtained as high as 91.7% with chip budding practiced on 15th July (T1M3). Higher percentage of such plants obtained on 15th July with chip budding is attributed to proper and quick union formation, early bud sprout and longer period of time available for growth. Similar results by Joolka and Rindhe (2000) obtained the highest proportion of saleable plants (98.324%) in chip budding, followed by T-budding in pecan nut. The minimum saleable plants (53.7%) were recorded in T6M4 (30th September + ring budding).

TABLE 1
EFFECT OF TIME OF BUDDING AND METHODS OF BUDDING ON GROWTH, SURVIVAL, AND SALEABLE PARAMETERS OF APRICOT BUDDED ON PEACH SEEDLING ROOTSTOCK

Treatment	Days taken to bud sprout	Length of longest bud sprout (cm)	Diameter of thickest sprout (cm)	Number of branches per budded plant	Number of leaves	Leaf area (cm^2)	Dead budded plants without sprouting (%)	Dead budded plants after sprouting (%)	Survival (%)	Saleable (%)
Factor A										
T1	78.5e	48.25a	0.878a	25.333a	115.7a	26.20b	14.08d	14.58a	71.25a	79.75b
T2	77.8e	28.42b	0.754b	24.25b	91.0b	26.15b	14.08d	17.42b	68.25b	81.25a
T3	172.0c	25.67c	0.758b	18.333c	66.0c	24.03c	14.83c	17.25c	67.67c	77.75c
T4	167.9d	23.50d	0.748c	18.667c	47.2d	23.07d	14.92c	16.50d	67.08d	69.25e
T5	174.3b	21.17e	0.742c	17.583d	31.4e	32.45a	18.25b	8.92e	42.17e	71.83d
T6	181.7a	20.58f	0.716d	15.500e	30.6f	26.15b	25.67a	22.75f	40.08f	62.67f
Factor B										
M1	141.7c	29.8a	0.778a	20.1b	70.5a	23.45d	17.6a	18.17b	64.4b	79.7a
M2	142.8b	27.9b	0.751b	22.5a	60.5c	29.42a	16.4b	12.11d	51.3d	76.7b
M3	135.3d	28.8c	0.779a	19.1c	69.2b	26.33b	16.2b	15.89a	67.9a	71.2c
M4	148.5a	25.2d	0.756b	18.1d	59.4d	26.17c	17.7a	18.78c	53.9c	67.3d

[1]Means in the same column followed by the same lowercase letter(s) are not significantly different at $p \leq 0.05$ according to Duncan's Multiple Range Test (DMRT).

[2]Factor A: Time of budding; Factor B: Methods of budding.

[3]T1 = 15 July, T2 = 30 July, T3 = 15 August, T4 = 30 August, T5 = 15 September, T6 = 30 September. M1 = T-budding, M2 = Patch budding, M3 = Chip budding, M4 = Ring budding.

TABLE 2

INTERACTION EFFECTS OF TIME AND METHOD OF BUDDING ON GROWTH, SURVIVAL, AND SALEABLE PARAMETERS OF APRICOT BUDDED ON PEACH SEEDLING ROOTSTOCK

Treatment	Days taken to bud sprout	Length of longest bud sprout (cm)	Diameter of thickest sprout (cm)	Number of branches per budded plant	Number of leaves	Leaf area (cm^2)	Dead budded plants without sprouting (%)	Dead budded plants after sprouting (%)	Survival (%)	Saleable (%)
T1M1	85.3l	49.0b	0.87b	25.0bc	117b	25.7i	13.7k	15.3f	70.3c	81.3g
T1M2	80.3m	45.7c	0.84c	25.7b	112c	25.9h	17.7fg	19.7c	62.3g	75.7i
T1M3	70.0p	53.3a	0.95a	27.3a	129a	28.5e	8.3n	6.7g	85.0a	91.7a
T1M4	78.3mn	45.0c	0.85c	23.3d	105d	24.7k	16.7hi	16.7e	67.0d	70.3m
T2M1	76.3n	30.3d	0.78e	25.7b	99e	27.4f	13.3k	18.3d	67.7d	86.7d
T2M2	78.7m	27.3f	0.74g	25.3bc	93f	25.7i	11.7l	17.7d	70.3c	77.3h
T2M3	73.0o	29.7d	0.71hi	24.3cd	89g	26.4g	14.7j	15.3f	69.7c	83.7f
T2M4	83.3l	26.3g	0.78e	21.7e	83h	25.1j	16.7hi	18.3d	65.3f	77.3h
T3M1	168.0ij	28.7e	0.81d	19.7f	79i	23.0n	17.3gh	20.3c	64.7f	89.7c
T3M2	176.3f	26.3g	0.74g	18.7fg	68k	25.0j	18.3f	16.7e	64.7f	90.7b
T3M3	160.3k	26.3g	0.76f	16.7ij	72j	24.2l	10.3m	15.3f	74.7b	62.3p
T3M4	183.3b	21.3k	0.71hi	18.3gh	45n	23.9m	13.3k	16.7e	66.7de	68.3n
T4M1	166.3j	24.3h	0.76f	19.3fg	49l	22.6p	15.3j	16.3e	66.7de	68.3n
T4M2	170.3gh	23.3i	0.74g	19.7f	47m	22.8o	16.3i	16.7e	66.7de	69.7m
T4M3	159.0k	24.7h	0.76f	18.3gh	49l	23.0n	14.7j	16.3e	69.3c	71.3l
T4M4	176.0f	21.7jk	0.72h	17.3hi	44no	23.9m	13.3k	16.7e	65.7ef	67.7n
T5M1	175.0f	22.3j	0.74g	17.3hi	41.7p	23.0n	19.3e	15.3f	67.7d	85.7e
T5M2	169.0hi	21.7jk	0.74g	21.0e	21.0t	41.9b	17.3gh	1.0h	24.3l	74.7j
T5M3	172.3g	20.3l	0.76f	15.7j	43.0o	21.9q	21.7d	18.3d	60.3n	60.3q
T5M4	181.0cd	20.3l	0.72h	16.3ij	20.0q	43.0a	14.7j	1.0h	16.3h	64.7o
T6M1	179.0de	24.3h	0.69j	13.7k	38.0u	19.0r	26.3c	23.3b	49.7i	66.7o
T6M2	182.0bc	23.3i	0.70ij	24.7bc	21.7t	35.2c	17.3gh	1.0h	48.7m	72.7k
T6M3	177.0ef	18.3m	0.72h	12.3l	33.0r	34.0d	27.7b	23.3b	19.3j	57.7r
T6M4	189.0a	16.3n	0.74g	11.3l	29.7s	16.4s	31.3a	43.3a	42.7k	53.7s

[1]Means in the same column followed by the same lowercase letter(s) are not significantly different at $p \leq 0.05$ according to Duncan's Multiple Range Test (DMRT).

[2]Factor A: Time of budding; Factor B: Methods of budding.

[3]T1 = 15 July, T2 = 30 July, T3 = 15 August, T4 = 30 August, T5 = 15 September, T6 = 30 September. M1 = T-budding, M2 = Patch budding, M3 = Chip budding, M4 = Ring budding.

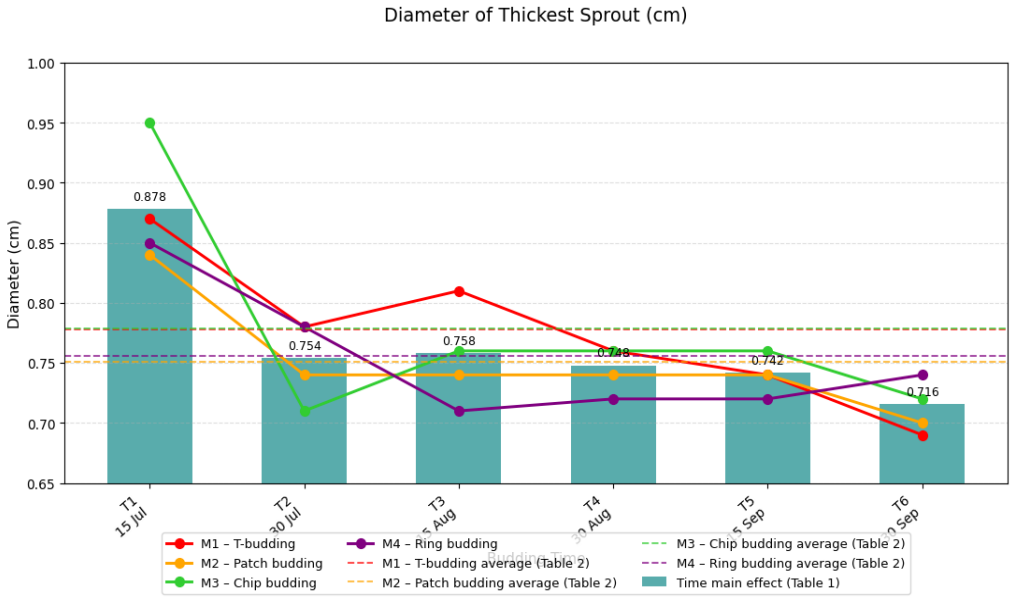


FIGURE 1: Effect of Budding Time (Factor A) and Method (Factor B) on Diameter of Thickest Sprout

Caption: Bars represent the main effect of budding time (Factor A – Table 1). Colored solid lines with markers represent the interaction effects (Time × Method combinations – Table 2). Dashed colored lines represent the main effect averages of budding methods (Factor B – Table 1). T1 = 15 July, T2 = 30 July, T3 = 15 August, T4 = 30 August, T5 = 15 September, T6 = 30 September. M1 = T-budding, M2 = Patch budding, M3 = Chip budding, M4 = Ring budding.

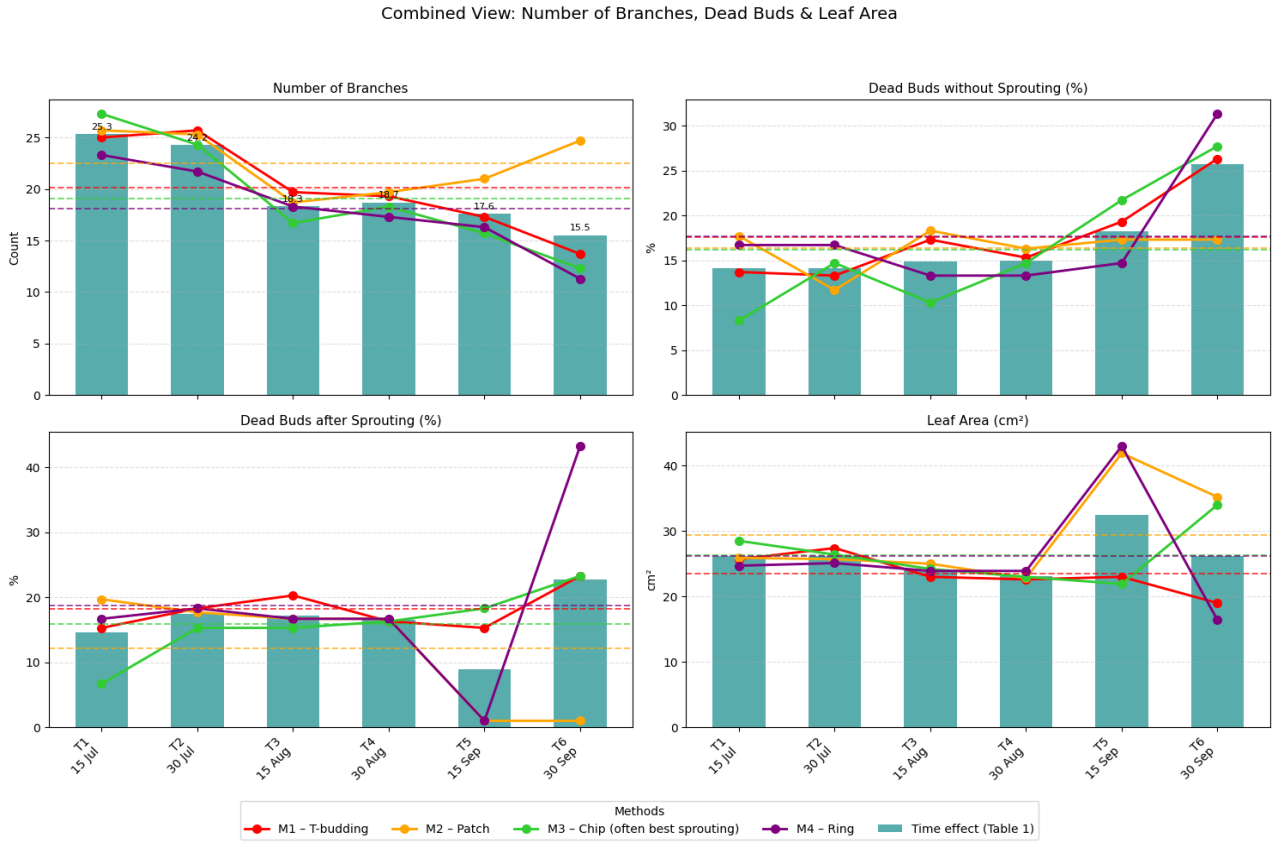


FIGURE 2: Influence of Budding Time (Factor A) and Method (Factor B) on Key Growth and Survival Parameters

Caption: Bars represent the main effect of budding time (Factor A – Table 1). Colored solid lines with markers represent the interaction effects (Time × Method combinations – Table 2). Dashed colored lines represent the main effect averages of budding methods (Factor B – Table 1). T1 = 15 July, T2 = 30 July, T3 = 15 August, T4 = 30 August, T5 = 15 September, T6 = 30 September. M1 = T-budding, M2 = Patch budding, M3 = Chip budding, M4 = Ring budding.

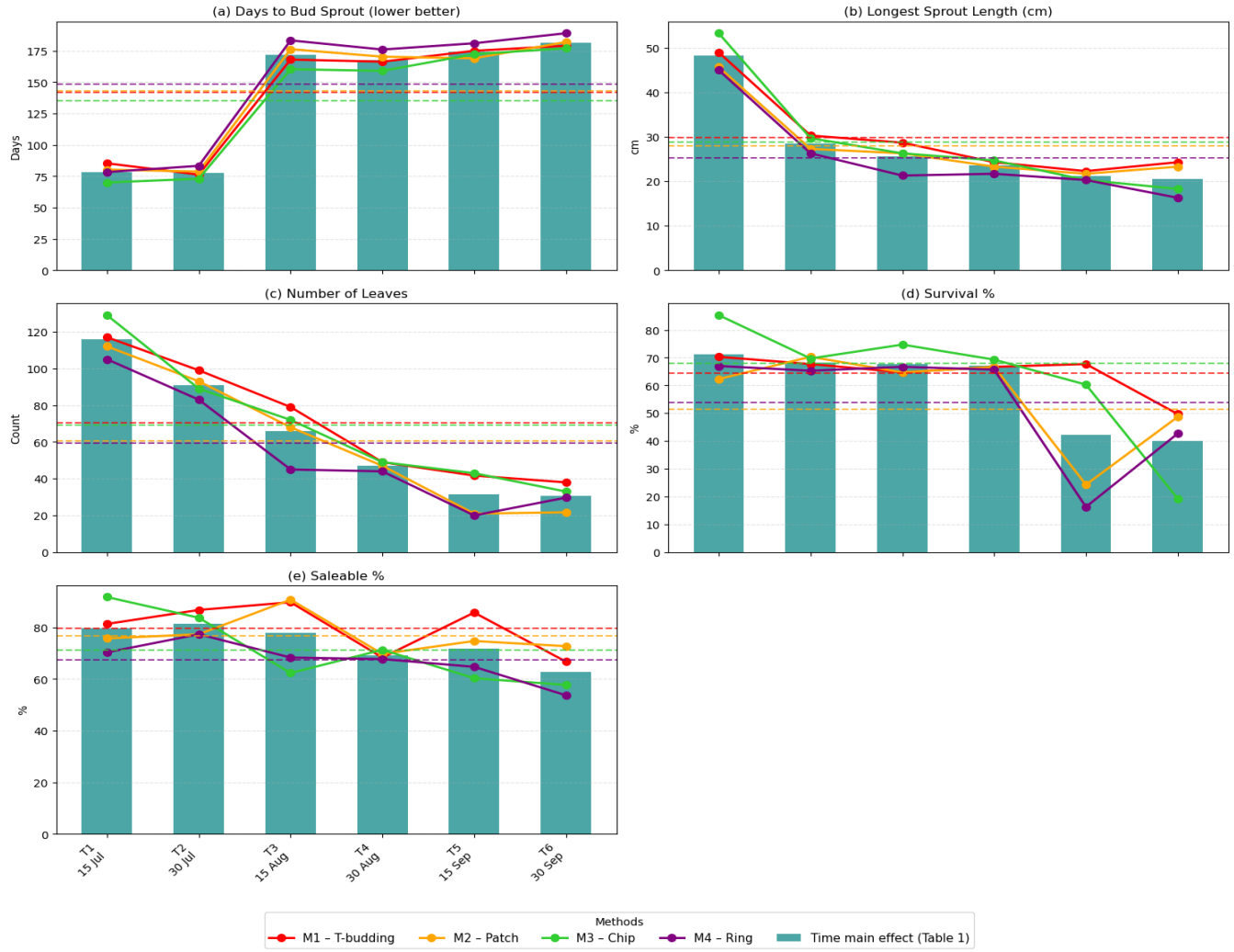


FIGURE 3: Influence of Budding Time (Factor A) and Method (Factor B) on Branches, Bud Failure Rates, and Leaf Area

Caption: Bars represent the main effect of budding time (Factor A – Table 1). Colored solid lines with markers represent the interaction effects (Time × Method combinations – Table 2). Dashed horizontal lines represent the main effect of budding method averages (Factor B – Table 1). T1 = 15 July, T2 = 30 July, T3 = 15 August, T4 = 30 August, T5 = 15 September, T6 = 30 September. M1 = T-budding, M2 = Patch budding, M3 = Chip budding, M4 = Ring budding.

IV. CONCLUSION

In this study, we found that when and how you bud apricot scions makes a significant difference in plant performance, especially under the mid-hill conditions of Garhwal Himalaya. Budding in mid-to-late July (15–30 July) clearly gave the best results across most parameters. Plants budded in this window sprouted the fastest (around 77–79 days), grew the longest shoots (up to 48 cm), had the thickest stems, produced more branches and leaves, and ended up with higher survival rates (71%) and a larger percentage of good-quality, saleable plants (up to 81%). The early monsoon timing—with good moisture, warm weather, and active sap flow—gave the buds the perfect chance to heal quickly and grow strong before winter.

When we compared the budding methods, chip budding stood out for getting sprouts to emerge quickly and keeping more plants alive. T-budding was better for longer shoots and more leaves. Ring budding, on the other hand, did not perform well in most cases.

The clear winner overall was chip budding done on 15th July (T1M3)—it sprouted the fastest (70 days), grew the strongest shoots (53.3 cm long, 0.95 cm thick), produced the most branches (27.3) and leaves (129), and delivered the highest survival (85.0%) and saleable plant percentage (91.7%). Budding later in September, by contrast, led to slow sprouting, weak growth, more dead buds, and far fewer plants worth selling.

Based on these findings, it is recommended that nursery operators in the Garhwal Himalayan region practice chip budding during mid-July for optimal success in apricot propagation on peach seedling rootstock.

CONTRIBUTION OF AUTHORS

Ria Rautela: Present idea, conduct of field research, manuscript writing, data analysis. Sadhana Bhatt and Namita Dabral: Visualization of data and structuring of manuscript.

COMPETING INTEREST

Authors have declared that no competing interests exist.

ACKNOWLEDGEMENT

The authors are thankful to VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand, India for providing all the facilities and support for this research. Appreciation is extended to all technical and field staff who assisted in the experiment.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Bourguiba, H., Audergon, J.-M., Krichen, L., Trifi-Farah, N., Mamouni, A., Trabelsi, S., D'Onofrio, C., Asma, B. M., Santoni, S., & Khadari, B. (2012). Loss of genetic diversity as a signature of apricot domestication and diffusion into the Mediterranean Basin. *BMC Plant Biology, 12*(1), 49. https://doi.org/10.1186/1471-2229-12-49

[2] Hartmann, H. T., Kester, D. E., Davies, F. T., & Geneve, R. L. (2002). *Hartmann and Kester's plant propagation: Principles and practices* (7th ed.). Prentice Hall.

[3] Hussain, S., Mir, M. M., Wani, S. A., Bhat, R., Shameem, R., & Ali, M. T. (2018). Effect of different budding methods and timings on budding success of chestnut (*Castanea sativa* Mill.). *International Journal of Current Microbiology and Applied Sciences, 7*(2), 1643–1649. https://doi.org/10.20546/ijcmas.2018.702.198

[4] McKey, D., Elias, M., Pujol, B., & Duputié, A. (2010). The evolutionary ecology of clonally propagated domesticated plants. *New Phytologist, 186*(2), 318–332. https://doi.org/10.1111/j.1469-8137.2010.03210.x

[5] Naithani, D. C. (2018). Evaluation of apricot cultivars and their hybrids under mid hill conditions of Garhwal Himalaya. *International Journal of Pure & Applied Bioscience, 6*(2), 976–986. https://doi.org/10.18782/2320-7051.8074

[6] Pawar, K. R., & Nema, P. K. (2023). Apricot kernel characterization, oil extraction, and its utilization: A review. *Food Science and Biotechnology, 32*(3), 249–263. https://doi.org/10.1007/s10068-022-01228-3

[7] Pawar, K. R., & Nema, P. K. (2023). Apricot kernel characterization, oil extraction, and its utilization: a review. *Food Science and Biotechnology, 32*(3), 249–263. https://doi.org/10.1007/s10068-022-01228-3

[8] Prakash, O., Jain, D., Nikumbhe, P., Srivastava, S., & Raghuvanshi, M. (2020). Significance, status and scope of apricot in India: A review. *International Journal of Chemical Studies, 8*(6), 5–11. https://doi.org/10.22271/chemi.2020.v8.i6a.10817

[9] Sharma, R., Gupta, A., Abrol, G. S., & Joshi, V. K. (2014). Value addition of wild apricot fruits grown in North–West Himalayan regions—A review. *Journal of Food Science and Technology, 51*(11), 2917–2924. https://doi.org/10.1007/s13197-012-0766-0

[10] Sheikh, Z. N., Sharma, V., Shah, R. A., Raina, S., Aljabri, M., Mir, J. I., AlKenani, N., & Hakeem, K. R. (2021). Elucidating genetic diversity in apricot (*Prunus armeniaca* L.) cultivated in the North-Western Himalayan provinces of India using SSR markers. *Plants, 10*(12), 2668. https://doi.org/10.3390/plants10122668