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STUDIES ON DIFFERENT BUDDING TECHNIQUES IN BAEI (*Aegle marmelos* L.) UNDER SUB-TROPICAL HUMID CONDITIONS.

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ABSTRACT

The present investigation entitled “Studies on Different Budding Techniques in Bael (*Aegle marmelos* L.) under Sub-Tropical Humid Conditions” was conducted at Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India. The experiment was laid out in a Factorial Randomized Block Design (FRBD) comprising four budding methods and five replications. Budding was performed at 15-day intervals from April 15 to July 15 under both open and shade-net conditions. Scion buds were collected from the bael cultivar Sabour Bael-1. Four budding techniques, namely patch, T- chip and forkert budding, were evaluated. The results revealed that The highest budding success was recorded when budding was performed on July 15 using the Patch Budding method, with success rates of 65.60% under open conditions and 66.80% under shade-net conditions. The minimum number of days required for first sprouting was observed in patch budding performed on July 15 recording 13.40 days under open conditions and 13.15 days under shade net conditions. The maximum sprout length at 45 days after budding was obtained with patch budding on July 15, measuring 25.08 cm under open conditions and 25.15 cm under shade-net conditions. Similarly, the highest number of sprouts per budded plant was recorded for patch budding on July 15 with 2.05 and 2.15 sprouts under open and shade net conditions, respectively. The maximum survival percentage after 90 days of budding was also observed in patch budding, registering 65.00% under open conditions and 66.80% under shade net conditions

Key words: Bael, Patch budding, chip buddind, T-budding, Forkert budding, Open, Shade net

Introduction

Bael (*Aegle marmelos* L.) is one of the most significant underutilized indigenous fruit crop in India. It is a member of the Rutaceae family. It can also be cultivated in Egypt, Bangladesh, Sri Lanka, Bhutan, Pakistan, Myanmar, and India. Bael is a subtropical fruit that may reach an altitude of 1200 m from sea level and can withstand temperatures as low as 7°C Bael trees are typically found in Indo-Gangetic plains, Sub-Himalayan tracts, and the northeastern region. Although bael is a subtropical tree, it is remarkably adaptable and thrives in tropical desert and semi-arid environments (Singh *et al.*, 2011). Bael is highly valued fruit in Ayurvedic medicine.

The pulp of the ripe fruit is delectable and can also be used to make goods with additional value such as jam, syrup, sweets and herbal beverages. The fruit has been popular in India since before its recorded history. It is a sacred tree honoring Lord Shiva and mention in Ramayana and Vedic literature. It can be cultivated at place where most of the fruit cannot be cultivated due to eroding soil and unfavourable weather conditions. The dry subtropical Zone of North India has been found to have a large variety of bael trees. Bael is highly variable in central India as well. Bael genotype are widely distributed throughout in Bihar plain and plateau region of Jharkhand especially in the dry, undulating and forest terrain. There are a large

number of races in North India. Superior bael plants have been effectively reproduced quickly using cotyledon nodes and axillary buds in the micropropagation procedure. However, to multiply bael accessions from explants taken directly from mother plants growing in the field, micro propagation methodology must be created for constituents such as alkaloids and steroids, which are also found in fruit. In the last decade, the ensured availability of elite planting stock of several high-yielding bael cultivars has given impetus to commercial bael production in many parts of India, especially the marginal areas of northwestern India suffering from soil salinity and in Western India from high temperature and moisture stress. At present, the commercial cultivation of the high-yielding bael variety Goma Yashi has recently gained momentum in Rajasthan, Uttar Pradesh, Madhya Pradesh, Punjab, Tamil Nadu, and Gujarat in the form of orchards or boundary plantations and has been planted on more than 150 ha in different parts of the country (Singh *et al.*, 2018). Approximately 1000 ha of land is under plantation of improved varieties of bael in the country, producing approximately 10,000 tons of fruits. Over the past few years, researchers have increasingly identified and validated plant-derived substances for the treatment of various human diseases. The Bael fruit is very nutritious and is rich source of vitamins and minerals, respectively. It contains 1.8 g protein, 0.39 g fat, 1.7 g minerals, 31.80 g carbohydrates, 55 mg carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1 mg niacin, and 8 mg vitamin C per 100 g of edible portion (Gopalan *et al.*, 1971). Different parts of the plant have been used in ethnomedicine as astringent, anti-diarrheal, anti-dysenteric, antipyretic, and antiulcer. In different varieties, variations in bark color (light yellow, gray, and dark gray) and bark splitting patterns (rectangular, cylindrical, triangular, and irregular) have been observed (Singh *et al.*, 2009). A wide range of variability with respect to leaf morphology (shape, margin, base, and apex) has been reported in the bael germplasm (Singh *et al.*, 2012). Nicotra *et al.*, (2011) also reported that different leaf shapes can be found in association with variation in other leaf traits due to different climatic factors. Variation in thorn orientation, number, size, and shape is found in different genotypes; thorns may be small and stout in pairs in most of the genotypes; three thorns can be seen rarely at a single node in a few genotypes, and it is also observed that the thorn converts into a pair of spines in very few genotypes. Goma Yashi trees are thornless under rain fed semi-arid conditions. However, these attributes may vary under different agro-climatic conditions. Most bael plantations are established using seedling-propagated materials, which exhibit genetic variability in tree vigor, bearing, fruit size,

shape, and quality. Due to variable genotypes, it is difficult to maintain genetic purity and uniformity in plant population seedlings, which begin to bloom in 7-8 years after planting. In contrast, vegetatively propagated trees begin to bloom in 3-4 years after planting. Hence, the multiplication of bael through vegetative means of propagation is essential to restore the genetic purity of commercial varieties or selected superior genotypes and their conservation. Bael is a minor fruit crop, and its planting material is in high demand because of its medicinal value and use in Ayurveda. Bael is propagated by seeds, which creates a large variability due to its heterozygous nature; however, budded plants do not have a heterozygous form. Vegetatively propagated fruit plants are true to type, and as a result, it is possible to achieve uniformity in the growth, yield, and quality of fruits. A number of workers have suggested that budding is the best methods, although the time of propagation varies from location to location (Tripathi and Kumar, 2004). Therefore, it is urgent to optimize the budding time and method for bael. Bael being a cross-pollinated crop, if propagated by seeds, shows a great amount of genetic variability in its population (Rai *et al.*, 1991).

Materials and Methods

The current experiment was conducted at the horticulture garden of the Bihar Agricultural University, Sabour, in 2022. The geographical location of Bhagalpur comes under the middle Gangetic plain region of Agro Climate zone III A. Four methods of budding, that is, patch budding, T-budding, chip budding, and Forkert budding, were used for bael propagation from 15th April to 15th July Bael (*Aegle marmelos* L.) The nursery budding operation was carried out in open and shade net conditions. There were four treatments with five replications in a factorial RBD design.

Results and Discussion

Success rate (%)

The data pertaining to the success rates of different budding methods on different budding dates and their interactions are presented in Table 1, Table 1.1, and Table 1.2, respectively. It is evident from Table 1 that under open field conditions, patch budding recorded the maximum success rate of 57.89 per cent, which was significantly superior to the other budding methods. Patch budding was followed by forkert budding (54.66%) and chip budding (52.54%). Under shade net conditions, patch budding proved superior to the remaining budding methods, achieving a success rate of 60.94 per cent, followed by Forkert budding (54.94%) and chip budding (52.80%). The minimum success rates of 51.46 per cent (open

Table 1: Effect of budding method (M) on success rate of buds.

Budding Method (M)	Open Condition	Shade net Condition
Patch Budding	57.89	60.94
T- Budding	51.46	52.54
Chip Budding	52.54	52.80
Forkert Budding	54.66	54.94
SEm ±	1.09	0.57
CD (P=0.05)	1.83	2.33
CV%	6.42	5.41

condition) and 52.54 per cent (shade net condition) were recorded for T-budding. The data regarding the effect of budding date on the success rate (%) are presented in Table 1.1. The maximum success rate of 56.60 per cent (open condition) and 58.00 per cent (shade net condition) was observed for budding performed on July 15, 2022, which was superior to the remaining dates. This treatment was found statistically at par with the budding dates of May 30, 2022 (55.75%), June 15, 2022 (55.40%), and June 30, 2022 (55.25%) under open conditions. In contrast, the minimum success rates of 47.00 per cent (open condition) and 54.25 per cent (shade net condition) were recorded on May 15, 2022. The interaction data between budding methods and dates are presented in Table 1.2. Under open field conditions, the maximum success rate of 65.60 per cent was recorded for patch budding performed on July 15, 2022, which was statistically at par with that of patch budding on June 30, 2022 (61.20%) and Forkert budding on July 15, 2022 (65.40%). A similar trend was observed under shade net conditions. The highest success rate of 66.80 per cent was recorded for patch budding on July 15, 2022, which showed statistically similar values with patch budding on June 30, 2022 (61.20%) and Forkert budding on July 15, 2022 (66.00%). The minimum success rates of 39.00 per cent (open condition) and 39.50 per cent (shade net condition) were observed in chip budding on May 15, 2022. The poor success rate observed on May 15, 2022, might be

Table 1.1: Effect of budding date (D) on success rate of buds.

Budding Date (D)	Open Condition	Shade net Condition
15.04.2022	51.70	55.60
30.04.2022	53.90	55.00
15.05.2022	47.00	54.25
30.05.2022	55.25	55.75
15.06.2022	55.40	55.80
30.06.2022	55.75	56.00
15.07.2022	56.60	58.00
SEm ±	0.92	0.48
CD (P=0.05)	2.16	2.75
CV%	6.42	5.41

Table 1.2: Budding method (M) and budding time (D) interaction on success rate of buds.

Budding Date (D)	Budding Method (M)	Open Condition	Shade net Condition
15.04.2022	Patch Budding	58.40	59.60
	T- Budding	56.40	57.80
	Chip Budding	55.60	57.40
	Forkert Budding	56.00	57.20
30.04.2022	Patch Budding	57.40	57.40
	T- Budding	49.80	49.80
	Chip Budding	53.40	53.80
	Forkert Budding	55.00	55.00
15.05.2022	Patch Budding	55.60	56.00
	T- Budding	56.00	56.00
	Chip Budding	39.00	39.50
	Forkert Budding	54.20	53.80
30.05.2022	Patch Budding	56.00	56.00
	T- Budding	55.20	55.20
	Chip Budding	56.60	57.00
	Forkert Budding	55.20	54.80
15.06.2022	Patch Budding	56.60	56.60
	T- Budding	55.40	56.40
	Chip Budding	55.20	55.20
	Forkert Budding	54.40	55.00
30.06.2022	Patch Budding	61.20	62.90
	T- Budding	60.40	62.40
	Chip Budding	60.60	60.50
	Forkert Budding	43.40	43.40
15.07.2022	Patch Budding	65.60	66.80
	T- Budding	43.00	48.20
	Chip Budding	40.40	53.40
	Forkert Budding	65.40	66.00
SEm ±		2.18	1.15
CD (P=0.05)		4.32	5.51
CV%		6.42	5.41

attributed to unfavorable environmental conditions for cambial growth of the scion and rootstock. The probable cause for this low success could be the low temperature and reduced sap flow in the rootstock, which leads to poor callus formation at the graft union. Temperature has a pronounced effect on callus tissue production and is the main factor influencing the success of budding. Temperature and humidity have a pronounced effect on callus tissue production. Favorable humid conditions promote faster union and higher graft success. Hartmann *et al.*, (2002), who emphasized that high humidity prevents desiccation of exposed tissues.

Day of first sprout

The data relating to days to first sprout for different budding methods on different budding dates and their interactions are presented in Table 2, Table 2.1, and Table

Table 2: Effect of budding method (M) on no. of days taken for 1st sprouting of bael saplings.

Budding Method (M)	Open Condition	Shade net Condition
Patch Budding	15.74	15.37
T- Budding	15.97	15.43
Chip Budding	16.03	15.51
Forkert Budding	16.94	16.71
SEm ±	0.24	0.36
CD (P=0.05)	0.57	0.86
CV%	6.67	10.33

2.2, respectively. It is evident from Table 2 that under open field conditions, patch budding took the minimum of 15.74 days to first sprouting, which was statistically at par with T-budding (15.97 days) and chip budding (16.07 days). A similar trend was observed under shade net conditions. Patch budding required the minimum number of days (15.37 days) for first sprouting, whereas T-budding (15.43 days) and chip budding (15.51 days) exhibited statistically similar values. In contrast, the maximum days for the first sprout were recorded in Forkert budding, taking 16.94 days under open conditions and 16.71 days under shade net conditions.

The data presented in Table 2.1 show the effect of budding on different dates. The minimum days to first sprout was recorded on 15 July 2022 with 13.40 days under open condition and 13.15 days under shade net condition, which was significantly superior over the remaining dates. In contrast, the maximum days of 18.15 days open condition) and 17.10 days shade net condition were found on 30 May 2022.

Based on the results obtained from Table 2.2, it is clear that the interaction between budding method and budding date significantly influenced days to first sprout. Under open field conditions, the minimum of 12.00 days was recorded for patch budding performed on 15 July

Table 2.1: Effect of budding date (D) on no. of days taken for 1st sprouting of bael saplings.

Budding Date (D)	Open Condition	Shade net Condition
15.04.2022	17.15	17.08
30.04.2022	16.30	15.90
15.05.2022	16.20	15.90
30.05.2022	18.15	17.10
15.06.2022	15.65	15.20
30.06.2022	16.35	15.75
15.07.2022	13.40	13.15
SEm ±	0.20	0.30
CD (P=0.05)	0.68	1.34
CV%	6.67	10.33

Table 2.2: Budding method (M) and budding time (D) interaction on no. of days taken for 1st sprouting of bael saplings.

Budding Date (D)	Budding Method (M)	Open Condition	Shade net Condition
15.04.2022	Patch Budding	16.80	16.80
	T- Budding	15.60	15.20
	Chip Budding	17.40	16.80
	Forkert Budding	18.80	20.40
30.04.2022	Patch Budding	17.60	17.40
	T- Budding	15.60	15.20
	Chip Budding	15.60	15.40
	Forkert Budding	16.40	15.60
15.05.2022	Patch Budding	15.60	15.40
	T- Budding	15.80	15.40
	Chip Budding	15.20	15.00
	Forkert Budding	18.20	17.80
30.05.2022	Patch Budding	17.60	16.80
	T- Budding	19.40	18.00
	Chip Budding	17.80	16.40
	Forkert Budding	17.80	17.20
15.06.2022	Patch Budding	14.00	13.40
	T- Budding	16.20	15.80
	Chip Budding	15.60	15.40
	Forkert Budding	16.80	16.20
30.06.2022	Patch Budding	15.80	15.40
	T- Budding	15.80	15.00
	Chip Budding	18.00	17.00
	Forkert Budding	15.80	15.60
15.07.2022	Patch Budding	12.00	11.80
	T- Budding	13.40	13.00
	Chip Budding	12.60	12.60
	Forkert Budding	14.80	14.20
SEm ±		0.48	0.72
CD (P=0.05)		1.35	2.04
CV%		6.67	10.33

2022, which exhibited statistically at par value with chip budding (12.60 days) on the same date. Under shade net conditions, patch budding on 15 July 2022 took the least time of 11.80 days for first sprout, which was found statistically at par with patch budding on 15 June 2022 (13.40 days) and chip budding on 15 July 2022 (12.60 days). In contrast, the maximum of 19.40 days (open condition) and 20.40 days (shade net condition) was taken by T-budding performed on 30 May 2022. Certain environmental requirements must be met for callus tissue to develop. The important factors are temperature and moisture. Temperature has a pronounced effect on the production of callus tissue. For better callusing and union, a particular temperature (optimum temperature) is required for each crop. Good sap flow in the bark and high temperature might be the factors which favor

Table 3: Effect of budding method (M) on no. of sprouts per graft.

Budding Method (M)	Open Condition	Shade net Condition
Patch Budding	1.97	2.03
T- Budding	1.71	1.80
Chip Budding	1.53	1.63
Forkert Budding	1.63	1.66
SEm±	0.12	0.13
CD (P=0.05)	0.29	0.33
CV%	31.77	34.70

callusing and proliferation at the bud union. Similar findings were also reported by Moti *et al.*, (1976) in peach, Joolka and Rindhe (2000) in peach and Tripathi and Kumar (2004) in bael.

Number of sprouts per graft

The data pertaining to number of sprouts per graft for different budding methods on different budding dates and their interaction are presented in Table 3, Table 3.1, and Table 3.2, respectively. The close study of data in Table 3 showed that under open field conditions, the maximum number of 1.97 sprouts per graft was produced by patch budding, which was exhibited statistically at par with Forkert budding (1.63 sprouts per graft). A similar trend was observed under shade net conditions, where the maximum number of 2.03 sprouts per graft was obtained by patch budding, which was at par with T-budding (1.80 sprouts per graft). In contrast, the minimum of 1.53 sprouts per graft (open condition) and 1.63 sprouts per graft (shade net condition) was recorded under chip budding. The data concerning number of sprouts per graft on different budding dates are presented in Table 3.1. Budding on different dates significantly affected the number of sprouts per graft. Under open field conditions, the budding dates of 30 May 2022 and 15 July 2022 produced the maximum equal value of 2.05 sprouts per

Table 3.1: Effect of budding date (D) on no. of sprouts per graft.

Budding Date (D)	Open Condition	Shade net Condition
15.04.2022	1.25	1.30
30.04.2022	1.35	1.40
15.05.2022	1.95	1.90
30.05.2022	1.75	1.90
15.06.2022	2.05	1.90
30.06.2022	1.80	2.10
15.07.2022	2.05	2.15
SEm±	0.10	0.11
CD (P=0.05)	0.35	0.39
CV%	31.77	34.70

Table 3.2: Budding method (M) and budding time (D) interaction on no. of sprouts per graft

Budding Date (D)	Budding Method (M)	Open Condition	Shade net Condition
15.04.2022	Patch Budding	1.60	1.80
	T- Budding	1.00	1.20
	Chip Budding	1.20	1.30
	Forkert Budding	1.20	1.20
30.04.2022	Patch Budding	1.40	1.60
	T- Budding	1.40	1.50
	Chip Budding	1.40	1.60
	Forkert Budding	1.20	1.20
15.05.2022	Patch Budding	2.20	2.40
	T- Budding	2.00	2.00
	Chip Budding	1.60	1.60
	Forkert Budding	2.00	2.00
30.05.2022	Patch Budding	2.40	2.50
	T- Budding	2.20	2.30
	Chip Budding	2.00	2.20
	Forkert Budding	1.80	2.00
15.06.2022	Patch Budding	2.00	2.20
	T- Budding	1.80	2.00
	Chip Budding	1.60	1.80
	Forkert Budding	1.60	1.80
30.06.2022	Patch Budding	2.00	2.20
	T- Budding	1.60	1.70
	Chip Budding	1.60	1.70
	Forkert Budding	1.60	1.80
15.07.2022	Patch Budding	2.50	2.60
	T- Budding	2.00	2.20
	Chip Budding	2.00	2.20
	Forkert Budding	2.00	2.20
SEm±		0.24	0.27
CD (P=0.05)		NS	NS
CV%		9.93	11.68

graft, which was found statistically at par with budding done on 30 May 2022 (1.95), 15 June 2022 (1.75) and 30 June 2022 (1.85). Under shade net conditions, the maximum of 2.15 sprouts per graft was recorded on 15 July 2022, which showed at par values with the dates of 15 May 2022 (1.90), 30 May 2022 (2.10) and 15 June 2022 (1.90). In contrast, the minimum of 1.25 sprouts per graft (open condition) and 1.30 sprouts per graft (shade net condition) was found on 15 April 2022.

Table 3.2 presents the interaction data between budding method and budding date on number of sprouts per graft. Under open field conditions, the maximum of 2.50 sprouts per graft was recorded for patch budding performed on 15 July 2022, which showed a non-significant effect. Under shade net conditions, a more or less similar trend was observed, with 2.60 sprouts per

Table 4: Effect of budding method (M) on Survival rate (%) of bud.

Budding Method (M)	Open Condition	Shade net Condition
Patch Budding	50.46	50.97
T- Budding	46.91	48.80
Chip Budding	48.66	49.69
Forkert Budding	48.94	50.69
SEm ±	0.17	0.84
CD (P=0.05)	0.72	NS
CV%	1.80	7.55

graft recorded for patch budding on 15 July 2022. In contrast, the minimum of 1.00 sprout per graft (open condition) and 1.20 sprouts per graft (shade net condition) was observed with T-budding performed on 15 April 2022. The higher number of sprouts per graft observed during favorable dates can be attributed to complete union of graft and early sprouting of graft shoot as influenced by congenial environmental conditions such as appropriate temperature, rainfall, and humidity. Favorable humid conditions promote good success and vigorous growth of sprouted buds. Singh *et al.*, (2011) reported that bael exhibits better growth under favorable moisture regimes. Tripathi and Kumar (2004) observed that environmental conditions prevailing at the time of budding significantly influence the sprouting behavior and subsequent shoot growth in bael. Sharma (2019) also documented that patch budding resulted in maximum shoot length and number of sprouts under optimal temperature and humidity conditions. Hartmann *et al.*, (2002) emphasized that adequate moisture and temperature are critical for callus proliferation and bud sprouting in woody perennials.

Survival percent of graft (%)

The data concerning survival percentage of grafts for different budding methods on different budding dates and their interaction are presented in Table 4, Table 4.1, and

Table 4.1: Effect of budding date (D) on Survival rate (%) of bud.

Budding Date (D)	Open Condition	Shade net Condition
15.04.2022	43.60	45.25
30.04.2022	45.10	45.70
15.05.2022	44.25	45.70
30.05.2022	45.00	46.50
15.06.2022	43.95	46.15
30.06.2022	54.75	55.35
15.07.2022	54.55	55.30
SEm ±	0.15	0.71
CD (P=0.05)	0.86	2.37
CV%	1.80	7.55

Table 4.2: Budding method (M) and budding time (D) interaction on survival rate of bud.

Budding Date (D)	Budding Method (M)	Open Condition	Shade net Condition
15.04.2022	Patch Budding	43.20	45.40
	T- Budding	45.20	47.00
	Chip Budding	42.60	44.80
	Forkert Budding	43.40	45.60
30.04.2022	Patch Budding	47.00	47.20
	T- Budding	43.80	44.20
	Chip Budding	45.40	45.40
	Forkert Budding	44.20	44.20
15.05.2022	Patch Budding	45.20	46.20
	T- Budding	41.60	43.60
	Chip Budding	35.80	37.00
	Forkert Budding	44.40	46.00
30.05.2022	Patch Budding	45.00	46.80
	T- Budding	45.80	47.40
	Chip Budding	43.20	44.80
	Forkert Budding	46.00	47.00
15.06.2022	Patch Budding	42.00	44.60
	T- Budding	43.20	45.40
	Chip Budding	45.20	47.20
	Forkert Budding	45.40	47.40
30.06.2022	Patch Budding	60.80	62.80
	T- Budding	59.60	61.80
	Chip Budding	59.20	60.20
	Forkert Budding	59.40	62.60
15.07.2022	Patch Budding	54.40	58.80
	T- Budding	44.20	48.20
	Chip Budding	54.20	53.40
	Forkert Budding	60.40	62.00
SEm ±		0.35	1.69
CD (P=0.05)		1.72	4.74
CV%		1.80	7.55

Table 4.2, respectively. Scrutiny of data in Table 4 indicates that under open field conditions, the highest survival percentage was recorded in patch budding (50.46%) , which was shown to be significantly superior over the rest of the budding methods. Under shade net conditions, patch budding also proved superior over the remaining budding methods, with a value of 50.97 per cent. The minimum survival of 46.91 per cent (open condition) and 48.80 per cent (shade net condition) was recorded in T-budding. The data with regard to the effect of budding date on survival percentage are presented in Table 4.1. The results showed that when budding was performed on 30 June 2022, the maximum survival of 54.75 per cent (open condition) and 55.35 per cent (shade net condition) was recorded, which was at par with the values of 54.55 per cent and 55.30 per cent on 15 July 2022. In contrast, the minimum survival of 43.60 per cent (open condition) and 45.25 per cent (shade net condition)

was found on 15 April 2022. Table 4.2 presents the interaction data between budding method and budding date on survival percentage of grafts. Under open field conditions, the maximum survival of 60.80 per cent was recorded, which was found statistically at par with 59.60 per cent (T-budding on 30 June 2022), 59.20 per cent (chip budding on 30 June 2022), 59.40 per cent (Forkert budding on 30 June 2022) and 60.40 per cent (Forkert budding on 15 July 2022). Under shade net conditions, a more or less similar trend was observed. The survival percentage of 62.80 per cent was recorded for patch budding performed on 30 June 2022, which showed at par values of 61.80 per cent (T-budding on 30 June 2022), 60.20 per cent (chip budding on 30 June 2022), 58.80 per cent (patch budding on 15 July 2022) and 62.00 per cent (Forkert budding on 15 July 2022). In contrast, the minimum survival of 35.80 per cent (open condition) and 37.00 per cent (shade net condition) was observed in chip budding performed on 15 May 2022. The success of survival from mid-June to mid-July performed better than other dates and months. The low survival observed on certain dates might be due to low temperature and low humidity. Similar results were obtained by Pandey and Prasad (1980) in aonla, who reported maximum bud survival during May, June, July and August by patch budding. Naik (1949) obtained maximum success in July with patch budding in cashew nut. Tripathi and Kumar (2004) also reported that patch budding gave the highest bud take (57.50%) in bael compared to other methods. Sharma (2019) observed that patch budding resulted in maximum percent bud intake (80.66%) under Jammu sub-tropics. Hartmann *et al.*, (2002) emphasized that temperature and humidity are the critical factors influencing graft union formation and subsequent survival of propagated plants.

Conclusion

The results of this study showed that both the budding technique and the budding period had a significant impact on the efficiency of bael propagation. Patch budding outperformed the other techniques in terms of bud formation, sprouting behavior, shoot growth, and plant survival in both open and shade-net conditions. Budding operations in June and July utilizing healthy 3–4-month-old scion shoots on 1.5-year-old rootstocks produced better propagation results. The most effective response was observed with patch budding during mid-July, which produced the highest budding success and vigorous growth of budded bael plants. Although it was still not as well as patch budding, forkert budding also functioned satisfactorily. Patch budding during the June–July period may be the most dependable and useful technique for

bael (*Aegle marmelos* L.) cv. Sabour Bael-1 multiplication in subtropical humid conditions, based on the overall performance of all treatments.

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