DOI : 10.5958/0974-0112.2021.00057.8

Indian J. Hortic. 78(4), December 2021: 398-403

Comparative evaluation of grafting and budding methods in jackfruit

Ravi Kumar, Pratibha, Ratna Rai* and Pradyot Nalini

Department of Horticulture, College of Agriculture, G.B.P.U.A.&T., Pantnagar - 263145, U.S. Nagar, Uttarakhand, India.

ABSTRACT

Inarching is the most widely practiced vegetative propagation method for multiplying jackfruit in the Tarai region. Still, the technique could be more convenient and produce more plants from a single mother plant. Therefore, the present experiment was conducted to find another alternative method for the commercial propagation of jackfruit. The study was conducted for twelve months with five methods of propagation, *viz*., inarching, wedge grafting, veneer grafting, patch budding, and ring budding. Earliest bud sprouting (18.08 days) with the highest survival (74.38%), the number of leaves (14.21), and the girth of new growth (5.93 mm) were recorded with wedge grafting performed in March. The highest number of primary branches (3.47) and length of primary root (15.36 cm) and secondary roots (32.84 cm) were obtained in plants multiplied through inarching in July. The maximum size of new growth (14.49 cm) at 90 days after grafting (DAG) was observed in wedge grafting performed in April. Based on the results, wedge grafting is the most appropriate propagation method to perform from December to April (best in March) under the tarai conditions of Uttarakhand. Therefore, wedge grafting can be practiced as an effective alternative method for jackfruit propagation instead of traditional inarching as the highest proportion of saleable grafted plants (77.56%) were also obtained through wedge grafting at 150 DAG.

Keywords: *Artocarpus heterophyllus* L., inarching, patch budding, wedge grafting.

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* L.), an important indigenous member of the family Moraceae is widely cultivated throughout the tropical and sub-tropical regions of India, Bangladesh, Myanmar, Thailand and Sri Lanka. The annual production of jackfruit in India accounts to 1830 thousand MT from an area of 185 thousand ha with an average productivity of 11.7 MT/ha (NHB, 10). Jackfruit has gained popularity as a super food due to its high nutritive value, and also referred as “Mutton on tree”. It is also known as the ‘Poor Man’s food’ in the eastern and southern parts of India (Bose and Mitra, 2), and popularly used in staple diet (Sreeni,13).

Jackfruit is commonly propagated through seeds, derived from zygotic embryos. Being a highly cross-pollinated crop, the seedling populations express huge variation with respect to maturity period and yield, size, shape, flesh colour and quality of fruits with prolonged juvenile phase (8-10 years). Hence, for commercial plantation of superior varieties, vegetative propagation is the only way to get genetically uniform plants. By and large, grafting and budding is relatively difficult in jackfruit, possibly due to the presence of milky latex, which hinders in the normal process of callus formation resulting in poor formation of graft union (Soepadmo, 12). Pant Garima is a high yielding (4-5 quintal/tree having average fruit weight of 5 kg) variety of jackfruit with excellent coocking qualities, which has been developed through clonal selection by our Depertment. It The planting material of this variety is in great demand , particularly in the *tarai* and *bhavar* regions of Uttarakhand state.

Several vegetative methods to multiply jackfruit including micropropagation have been reported with fair to good success (Divyangana, 4; Khatun *et al*., 8; Kuddus, 9; Vijayakumar *et al.,* 15). However, in the *tarai* region of Uttarakhand, jackfruit is commonly propagated by inarching, which has certain serious limitations (cumbersome, time consuming and low number of plants production per mother plant) for large scale production of elite planting materials (APAARI, 1). Hence, the present experiment was undertaken to assess the possibility of other alternative method of propagation and appropriate timing of operation for the large scale multiplication of quality planting materials of Pant Garima jackfruit.

MATERIALS AND METHODS

The present study was conducted at Horticulture Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, in jackfruit cv. Pant Garima. The experimental site is situated in the *tarai* region of Uttarakhand, and is characterized by humid subtropical climate. Five propagation methods namely, inarching, wedge grafting, veneer grafting, patch budding and ring budding were attempted at monthly

*Corresponding author: ratnarai1975@gmail.com

intervals (15th day of every month) from February, 2018 to January, 2019. The average monthly data on temperature and relative humidity prevailing during the course of study are presented in Table 1. Healthy and vigorously growing 10-12 months old seedlings which had attained an average thickness of 10-12 mm were used as rootstocks. In inarching, about 30-35cm scion portion was retained above the point of graftage. The scion shoots of 15-18 cm length, 10-12 mm thickness and with 3-4 healthy buds were used for wedge and veneer grafting. The selected shoots were defoliated on the mother plant, 7-8 days prior to grafting for the forcing of the dormant buds to swell. The apical portion of shoots was removed. The wedge grafted plants were covered with polycaps. For patch and ring budding, the scion sticks with swollen buds were freshly collected. All the budding and grafting operations except inarching were performed under shade net (50 %). The grafting and budding operations (except inarching) were performed on the rootstock, at a height of 10-12 cm from the ground level. The observations for survival percentage and number of days taken for bud sprouting in all the methods except in inarching were recorded at 60 days after grafting (60 DAG). The scion in the inarched plants were detached from mother plant at 60 DAG, therefore it was difficult to ascertain the success of graftage survival at the time of recording of data. The length and girth of new growth was recorded with the help of a meter scale and Vernier callipers, respectively. Number of leaves and number of primary branches were visually counted, while the length of primary roots was measured with the help of measuring scale (on the successful grafts only). The percentage of saleable jackfruit plants were assessed as: saleable plants (%) = Number of saleable plants/ Total number of plants propagated × 100.

The experiment was laid out in factorial randomized block design with four replications. The data were analysed as per the procedure of Panse and Sukhatme (11) using OPSTAT software.

Table 1. Average monthly weather data during the period of investigation

Month	Temperature (°C)		Relative Humidity (%)	
	Max.	Min.	7.00 am	2.00 pm
Feb-18	25.45	9.45	92.00	51.50
Mar-18	31.53	12.43	83.50	42.50
Apr-18	34.53	17.90	74.25	39.00
May-18	36.85	22.15	69.35	39.55
Jun-18	35.60	25.33	78.28	56.73
Jul-18	33.1	26.12	86.36	73.84
Aug-18	30.82	25.22	92.1	79.88
Sep-18	31.68	23.55	91.20	74.25
Oct-18	30.74	15.12	86.4	57.12
Nov-18	26.68	11.18	93.80	58.00
Dec-18	22.30	5.53	95.23	56.00
Jan-19	21.20	6.62	91.80	56.60

RESULTS AND DISCUSSION

The data (Table 2) revealed that the plants which were wedge grafted during March took the minimum time for bud sprouting (18.08days), and was closely followed by veneer grafting (19.64 days) performed in April and patch budding (19.79 days) performed in August. In general, it was observed that out of 12 months of experimentation, bud sprouting in the grafted plants was observed in 5 months in wedge grafting followed by veneer grafting (4 months) and patch and ring buddings (3 months in each). Maximum duration for bud sprouting (47.54 days) was recorded in ring budding, performed in June. It was observed that in ring budding, although callusing occurred at the bud union, but it did not positively helped in sprouting of buds even in the months, when ring budding was successful. The earlier bud sprouting in the wedge grafted plants was observed when performed during March. The gradual rise in atmospheric temperature during March might have helped in better healing and swelling of buds in the wedge grafted plants, eventually resulting in early sprouting. The polycaps used in wedge grafting helped in creation of better microclimate around the graft union by maintaining proper humidity and providing protection against desiccation of active tissues of scion (Visen *et al*., 16).Wedge grafting performed during February – March has also been reported to be highly successful in other fruit crops too (Das *et al*., 3; Joshi *et al*.,7).

With respect to survival percentage of grafted plants, June was the most favourable month (45.44 %), while none of the methods proved successful during September, October and November. Highest survival percentage of graftage (74.38%) was observed in wedge grafting performed in March followed by veneer grafting performed in April (66.67 %). During December and January, despite of very low temperature , only the wedge grafted plants could survive better at 60 DAG than other methods tested. The higher survival percentage of wedge and veneer grafted plants could also be attributed to greater length of the scion having more reserved food material which might have helped the grafted plants to overcome the adverse weather conditions in a better manner as compared to patch and ring budding, where the scion comprised of a single bud only. The

Table 2. Effect of methods and time of propagation on number of days taken for bud sprouting and survival percentage at 60 DAG.

Time of graftage	Days taken for bud sprouting (days)						Survival (%)					
	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean
February	-	20.29	0.00	0.00	0.00	5.07	-	52.57	0.00	0.00	0.00	13.14
March	-	18.08	23.22	0.00	0.00	10.33	-	74.38	50.03	0.00	0.00	30.63
April	-	21.76	19.64	0.00	0.00	10.35	-	60.87	66.67	0.00	0.00	31.88
May	-	0.00	21.42	0.00	0.00	5.36	-	0.00	64.29	0.00	0.00	16.07
June	-	0.00	20.44	21.16	47.54	22.29	-	0.00	58.34	61.54	61.91	45.44
July	-	0.00	0.00	20.15	38.64	15.20	-	0.00	0.00	64.29	66.08	32.59
August	-	0.00	0.00	19.79	42.14	15.48	-	0.00	0.00	58.34	65.22	30.89
September	-	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00
October	-	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00
November	-	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00
December	-	23.61	0.00	0.00	0.00	5.90	-	51.48	0.00	0.00	0.00	12.50
January	-	21.53	0.00	0.00	0.00	5.38	-	53.63	0.00	0.00	0.00	13.41
Mean	-	8.77	7.06	5.93	10.69		-	23.54	20.54	15.35	16.11	
Factors			$CD_{(0.05)}$		SE(m)				$CD_{(0.05)}$		SE(m)	
Time (T)			0.21		0.08				0.38		0.14	
Propagation Method (M)			0.12		0.04				0.22		0.08	
T × M			0.43		0.15				0.76		0.27	

Table 3. Effect of methods and time of propagation on primary branches and number of leaves at 90 DAG.

Time of graftage	Number of primary branches						Number of leaves/ plant					
	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean
February	2.62	1.68	0.00	0.00	0.00	0.86	7.53	12.27	0.00	0.00	0.00	3.96
March	2.38	2.02	2.12	0.00	0.00	1.30	7.74	14.21	12.59	0.00	0.00	6.87
April	2.54	1.54	1.78	0.00	0.00	1.17	8.08	13.36	13.72	0.00	0.00	7.03
May	2.66	0.00	1.63	0.00	0.00	0.86	8.44	0.00	13.33	0.00	0.00	4.35
June	3.29	0.00	1.54	1.76	1.12	1.54	8.90	0.00	12.29	12.33	7.11	8.13
July	3.47	0.00	0.00	2.18	1.75	1.48	9.37	0.00	0.00	14.01	9.97	6.67
August	3.00	0.00	0.00	1.83	1.46	1.26	9.08	0.00	0.00	11.90	9.25	6.05
September	2.03	0.00	0.00	0.00	0.00	0.41	8.31	0.00	0.00	0.00	0.00	1.66
October	2.63	0.00	0.00	0.00	0.00	0.53	7.73	0.00	0.00	0.00	0.00	1.55
November	2.60	0.00	0.00	0.00	0.00	0.52	7.28	0.00	0.00	0.00	0.00	1.46
December	2.57	1.13	0.00	0.00	0.00	0.74	6.85	12.71	0.00	0.00	0.00	3.91
January	2.25	1.34	0.00	0.00	0.00	0.72	6.72	13.09	0.00	0.00	0.00	3.96
Mean	2.67	0.64	0.59	0.48	0.36		8.00	5.45	4.33	3.19	2.19	
Factors			$CD_{(0.05)}$		SE(m)				$CD_{(0.05)}$		SE(m)	
Time (T)			0.07		0.03				0.07		0.02	
Propagation Method (M)			0.05		0.02				0.04		0.02	
T×M			0.16		0.06				0.15		0.05	

highest success in wedge grafting performed in March could also be due to better callusing at the graft union leading to early differentiation of vascular cambium across the callus bridge and production of secondary xylem and phloem.

The results (Table 3) showed that the inarching performed in all months yielded in successful grafts as reflected by number of primary branches at 90 DAG. Remarkably, higher number of primary branches (3.47) was observed in inarching performed during July, which was closely followed by June (3.29), while it was lowest (1.12) in ring budding performed in June. In inarching, the presence of 3-4 buds on scion and its attachment with mother plant for a longer duration (60 days) might have resulted in higher number of primary branches as compared to other methods. Similarly, significant differences in the number of leaves on grafted/budded plants were also observed as affected by propagation methods and time of operation (Table 3). It was observed that although number of primary branches was relatively lesser in wedge grafting performed during March (as compared to inarching) but number of leaves per plant were quite higher (14.21) than the other methods. Inarching performed in January, however registered minimum number of leaves (6.72). Better results in terms of production of leaves in wedge grafted plants of jackfruit have also been observed by Khatun *et al*. (8).

The length and diameter of newly emerged shoots were also significantly influenced by different months and methods of propagation (Table 4). From the data, it is evident that the maximum length of new growth (14.49 cm) was observed in wedge grafting performed during April, followed by veneer grafting in March (13.43 cm). The minimum length of new shoot (4.99 cm), however, was observed in the plants, inarched in the month of January. Overall, the mortality rate of grafted plants in case of inarching (over 12 months) was less because the scion was attached to the mother plant for at least 60 days (before detachment), and received regular supply of food materials for longer duration. Among the wedge grafting, performed during various months, minimum increment in the length of new shoot (12.14 cm) was found during December, when the atmospheric temperature was very low but thereafter, an increasing trend in length of new growth was observed with the rise in temperature from December to April. In general, inarching, wedge and veneer grafting were found superior over patch and ring budding with respect to length of new growth

Table 4. Effect of methods and time of propagation on the length and diameter of new shoot at 90 DAG.

Time of graftage	Length of shoot (cm)						Diameter of new shoot (mm)					
	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean
February	5.21	12.70	0.00	0.00	0.00	3.58	4.29	5.03	0.00	0.00	0.00	1.86
March	5.71	13.61	12.23	0.00	0.00	6.31	4.46	5.93	5.00	0.00	0.00	3.08
April	6.05	14.49	13.43	0.00	0.00	6.79	4.73	5.41	5.13	0.00	0.00	3.05
May	6.85	0.00	12.91	0.00	0.00	3.95	4.88	0.00	5.40	0.00	0.00	2.18
June	7.44	0.00	12.59	12.03	6.81	7.77	5.38	0.00	5.29	5.00	3.24	3.78
July	8.55	0.00	0.00	13.09	8.68	6.06	5.80	0.00	0.00	5.35	4.80	3.26
August	7.65	0.00	0.00	11.56	7.76	5.40	5.45	0.00	0.00	4.69	4.66	2.96
September	6.67	0.00	0.00	0.00	0.00	1.33	5.16	0.00	0.00	0.00	0.00	1.03
October	5.60	0.00	0.00	0.00	0.00	1.12	4.48	0.00	0.00	0.00	0.00	0.90
November	5.35	0.00	0.00	0.00	0.00	1.07	4.55	0.00	0.00	0.00	0.00	0.91
December	5.08	12.14	0.00	0.00	0.00	3.44	4.38	4.85	0.00	0.00	0.00	1.85
January	4.99	12.31	0.00	0.00	0.00	3.46	4.30	4.98	0.00	0.00	0.00	1.86
Mean	6.26	5.44	4.26	3.06	1.94		4.82	2.18	1.79	1.28	1.06	

Factors	$CD_{(0.05)}$	SE(m)	$CD_{(0.05)}$	SE(m)
Time (T)	0.09	0.03	0.03	0.01
Propagation Method (M)	0.06	0.02	0.02	0.01
T×M	0.19	0.07	0.07	0.02

which again might be due to more length of scion. The higher length of scion in grafting resulted in faster sprout growth as compared to single bud in the budding methods (Tripathi and Karunakaran, 14). Higher increment in plant height of jamun plants grafted in March as compared to grafting performed during other months of the year (Gadekar *et al*., 6).The data revealed that the maximum diameter of new growth (5.93mm) was observed in wedge grafting performed in March, followed by inarching in July (5.80 mm). The thinnest new growth, however, was observed in ring budding performed in June (3.24 mm). The thickest stem growth in wedge grafted plants performed in March has also been reported in guava (Dixit *et al*., 5) and apple (Das *et al*., 3).

The results presented in Table 5 revealed that in general, there was better root production in inarching, wedge grafting and veneer grafting than budding methods indicating better translocation of photosynthates from the scion to the rootstock encouraging more growth of the roots. The longest primary (15.36 cm) and secondary (32.84 cm) roots was recorded in inarching performed in July, while these were lowest (primary roots-10.70 cm and secondary roots -19.72) in wedge grafting (December) and inarching (March), respectively. In the present experiment, based on pooled data (Fig. 1), it was found that the highest percentage of saleable plants after 150 days of grafting were obtained in wedge grafting (77.56 %) as compared to veneer grafting (53.48 %), inarching (37.11 %), patch budding (22.38 %) and ring budding (10.05 %). Better scion and rootstock connection and optimum temperature available for callusing might have resulted in stronger graft union leading to overall better growth of the wedge grafted plants.

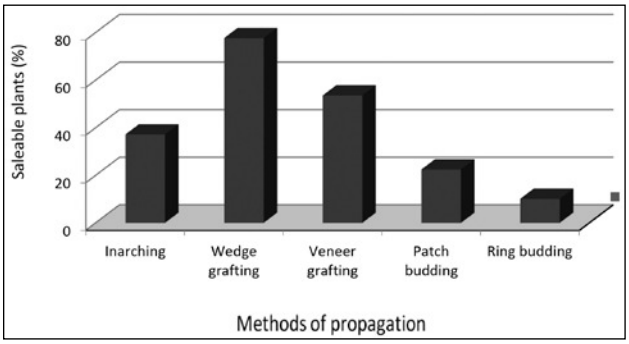

Fig. 1. Proportion of saleable plants percentage after 150 days after grafting.

Table 5. Effect of methods and time of propagation on length of primary root and secondary roots at 90 DAG

Time of graftage	Length of primary root (cm)						Length of secondary roots (cm)					
	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean A	Inarching	Wedge grafting	Veneer grafting	Patch budding	Ring budding	Mean A
February	13.33	13.28	0.00	0.00	0.00	5.32	25.72	28.79	0.00	0.00	0.00	6.90
March	13.51	13.06	13.09	0.00	0.00	7.93	19.72	29.81	27.03	0.00	0.00	15.21
April	13.14	12.73	12.49	0.00	0.00	7.67	22.04	27.89	25.83	0.00	0.00	15.15
May	12.38	0.00	12.04	0.00	0.00	4.88	24.09	0.00	24.23	0.00	0.00	9.66
June	12.43	0.00	11.50	12.03	11.42	9.48	30.82	0.00	22.76	24.00	24.36	20.39
July	15.36	0.00	0.00	13.39	13.14	9.18	32.84	0.00	0.00	27.35	28.20	17.68
August	14.16	0.00	0.00	12.28	11.95	7.68	28.42	0.00	0.00	25.64	26.21	16.05
September	14.58	0.00	0.00	0.00	0.00	2.92	28.74	0.00	0.00	0.00	0.00	5.75
October	15.01	0.00	0.00	0.00	0.00	3.00	25.67	0.00	0.00	0.00	0.00	5.13
November	13.83	0.00	0.00	0.00	0.00	2.77	27.92	0.00	0.00	0.00	0.00	5.58
December	14.86	10.70	0.00	0.00	0.00	4.31	24.04	29.10	0.00	0.00	0.00	10.63
January	14.98	11.50	0.00	0.00	0.00	5.30	29.84	29.32	0.00	0.00	0.00	11.93
Mean B	13.96	5.11	4.09	3.14	3.04		26.65	10.41	8.32	6.42	6.56	

Factors	$CD_{(0.05)}$	SE(m)	$CD_{(0.05)}$	SE(m)
Time (T)	0.51	0.18	1.18	0.42
Propagation Method (M)	0.33	0.12	0.76	0.27
T×M	1.13	0.41	2.63	0.94

Based on above findings, it may be concluded that wedge grafting performed in March took the lowest duration for bud sprouting along with highest survival (74.38%) under shade conditions. The longest sprout at 90 DAG was obtained in wedge grafted plants performed in April closely followed by March, which also registered maximum diameter of new growth (5.93 mm). Inarching performed in July had the highest number of primary branches (3.47) and length of primary (15.36 cm) and secondary (32.84 cm) roots, but the number of leaves per graft was higher in wedge grafted plants performed in March.

Wedge grafting performed in March under shade net resulted in production of better quality plants in lesser time and therefore, can be successfully adopted as a potential alternative to inarching for large scale production of elite planting material of Jackfruit cv. Pant Garima under *tarai* conditions of Uttarakhand.

AUTHORS' CONTRIBUTION

Conceptualization of research (Pratibha and Ratna Rai), designing of experiment (Pratibha, Ratna Rai and Ravi Kumar), contribution of experimental material (Pratibha), execution of experiment and data collection (Ravi Kumar and Pradyot Nalini), Data analysis and interpretation (Ravi Kumar), Preparation of manuscript (Pratibha, Ravi Kumar and Ratna Rai).

DECLARATION

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

1. APAARI. 2012. *Jackfruit Improvement in the Asia-Pacific Region-A Status Report*. Asia-Pacific Association of Agricultural Research Institutions, Bangkok, Thailand. 182 p.
2. Bose, T.K. and Mitra, S.K. 1990. *Fruits Tropical and Subtropical*, NayaProkash, Calcutta, 2: 541-65.
3. Das, B., Kishor, A. and Ahmed, N. 2018. Budding and grafting time and height as determining factors for bud take and successive plant growth in some temperate fruits. *Indian J. Hortic.* **75**: 326-31.
4. Divyangana,2017. Studies on effect of chitosan on micropropagation of jackfruit. *M.Sc. Thesis*, Department of Horticulture, G.B.P.U.A.&T., Pantnagar, 70 p.
5. Dixit, P., Kumar, A., Prakash, S., Kumar, M., Kumar, V., Shukla, S., Kumar, M. and Kumar, U. 2019. Effect of time, techniques and environment of propagation on performance of guava (*Psidium guajava*). *Indian J. Agric. Sci.* **89**: 415-19.
6. Gadekar, S.G., Bharad, V.P. and Patil, S. 2010. Seasonal variation in success of softwood grafting of jamun under Akola conditions. *Asian J. Hortic.* **2**: 266-68.
7. Joshi, P.S., Bhalerao, P. Mahorkar, V.K. and Jadhav, B.J. 2000. Studies on vegetative propagation in custard apple. *PKV Res. J.*, **24**: 103-105.
8. Khatun, M.J.M., Rahim, M.A., Islam, M.S. and Alam, K.H. 2006. Propagation of jackfruit by grafting as influenced by time and method of grafting and age of scion. *J. Bangladesh Soc. Agric. Sci. Technol.* **3**: 209-212.
9. Kuddus, M.A. 2001. Characterization and grafting performance of different accessions of jackfruit. *M.Sc. Thesis*, Department of Horticulture, Bangladesh Agril. Univ., Mymensingh. 118p.
10. NHB, 2018. *National Horticulture Board: Area and Production Statistics*. *http://nhb.gov.in*retrieved on 29.09.2020.
11. Panse, V.G. and Sukhatme, P.V. 2000. Statistical Methods for Agricultural Workers. Publication and Information Division. ICAR, New Delhi.
12. Soepadmo, E. 1991. *Artocarpus heterophyllus* Lam. In: *Plant Resources in South East Asia, No. 2. Edible fruits and Nuts*, E.W.M, Verheij and R.E., Coronal, (eds.) Wageningen, Netherlands, Pudoc: 86-91.
13. Sreeni, K.R. 2020. Jackfruit – Future food security: A case study of Ayur Jack farm of Thissur, Kerala. *Int. J. Adv. Res.*, **8** : 787 –90.
14. Tripathi, P.C. and Karunakaran, G. 2020. Standardization of propagation method in avocado (*Persea americana*). *Curr. Hortic.* **8**: 28–32.
15. Vijayakumar, K., Shivashanker, G. and Gowda, V.N. 1991. Propagation of jack *Artocarpus heterophyllus* Lam. by greenwood cleft grafting. *Crop Res.* **4:** 169 -70.
16. Visen A., Singh, J.N. and Singh, S.P. 2010. Standardization of wedge grafting in guava under the North Indian plains. *Indian J. Hortic.* **67**: 111-14.

Received : February, 2021; Revised : October, 2021; Accepted : November, 2021