Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 3035-3038
Received: 18-07-2020
Accepted: 23-08-2020

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Performance of inarching in jackfruit (*Artocarpus heterophyllus* L.) performed during different months under the *Tarai* region of Uttarakhand

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Abstract
The jackfruit is an emerging crop of India due to its various uses as fruits, vegetable medicinal, timber and wood. The present study was carried out in 2018- 19 to find the most appropriate time of inarching in jackfruit. The experiment ware laid out in one factorial randomized block design and was replicated four times. The experiment was consisted of 12 dates of inarching from February 2018- January 2019. The results obtained from the experiment revealed that the inarching performed in the month of July recorded the highest survival percentage (93.80%), length (8.55 cm) and diameter (5.80 mm) of new growth, number of primary branches (3.47), number of leaves (9.37), length of primary roots (32.84 cm) and dry root: shoot ratio (0.70) at 90 DAG, However, the maximum length of tap root (15.85 cm) and fresh root: shoot ratio were noted during the November (0.72) inarched plant. From the present finding, it can be concluded that under *Tarai* conditions of Uttarakhand inarching performed during July is the most suitable time for quality production of jackfruit plants of cv. Pant Garima.

Keywords: Jackfruit, vegetative propagation, inarching, rootstock, scion

Introduction
Jackfruit (*Artocarpus heterophyllus* L.) is a native fruit crop of India. It is widely cultivated throughout the tropical and sub-tropical countries including Bangladesh, India, Myanmar, Thailand, Sri Lanka and *etc*. In India, it is very popular in the states like Kerala, Tamil Nadu, Karnataka, Goa, Uttar Pradesh, Bihar, West Bengal and *etc*. Jackfruit tree thrives well in hot humid climate and can tolerate low temperature to some extend but is sensitive to chilling, cold and frost. It is also one of the most suitable fruit crop for dryland horticulture. It is an evergreen monoecious crop producing latex, growing up to a 20- 30 m in height and easily recognized by its fruit, the largest fruit among the cultivated plants with a long tap root and a dense crown (Bose and Mitra, 1990) [1]. Being a staple food, it is very popular among the poorer classes and Indian house for culinary preparations and so it is also known as the 'Poor Man's food' in the eastern and southern parts of India (Archana *et al*., 2018). It is quite important both for use as a fruit and vegetable. Jackfruit is most commonly propagated through seeds. Due to its highly cross-pollinated nature, immense variation is observed among populations with respect to yield, size, shape, flesh colour, quality of fruit and maturity period. Commercial cultivation of jackfruit is still at a primitive stage in India, primarily because of the difficulties in producing elite planting materials. Hence, vegetative propagation become essential in order to get true to type plants (Bose and Mitra, 1990) [1]. The significance of vegetative propagation over sexual propagation in the maintenance of genetic uniformity and preservation of identity of an elite clone or cultivar is well recognized in horticultural crops, Jackfruit is still considered very difficult species to propagate through vegetative means, possibly due to the presence of its milky latex, which creates problem in the normal process of callus formation and ultimately the formation of graft union (Soepadmo 1991) [18]. Therefore, there is an immense need to find out a suitable method of vegetative propagation, for rapid and large-scale multiplication of jackfruit plants. Hence, keeping the above points into consideration, the present study was undertaken to find out the most appropriate time of inarching technique for quality production of jackfruit plants in short span of time in jack fruit.

Materials and Methods
The present study was carried out during February, 2018 to January, 2019 at Horticulture Research Centre Patharchatta, G.B.P.U.A.T., Pantnagar, (Uttarakhand). The treatment consisted of 12 dates of grafting *i.e.* T_1 (15th February'18), T_2 (15th March'18), T_3 (15th

(15th April'18), T_4 (15th May'18), T_5 (15th June'18), T_6 (15th July'18), T_7 (15th August'18), T_8 (15th September'18), T_9 (15th October'18), T_{10} (15th November'18), T_{11} (15th December'18), T_{12} (15th January'19). Healthy and vigorously growing one year old seedlings which had attained an average height of 60-70 cm with 8-10 mm thickness were used as rootstock for the inarching. About 30-35 cm scion portion was retained above the point of graftage and it was detached from the mother plant at 60 DAG. All observations were recorded from four randomly selected plants from each replication and treatment at 90 days after inarching (ADG) except survival percentage (at 75 DAG). The graft survival percentage was calculated by counting the number of grafts surviving after 75 days of inarching and expressed in percentage. Length and diameter of new growth was measured with the help of a meter scale and digital vernier callipers at 90 DAG. The average number of primary branches and leaves per graft was recorded at 90 DAG. The fresh weight of shoot and root was measured with the help of weighing balance. The length of tap and secondary roots was measured from the point of their emergence to the apex with the help of measuring scale. The experiment was laid out in one factorial randomized block design and was replicated four times. The data was analysed as per the procedure suggested by Snedecor and Cochran (1967) [17].

Result and Discussion

Data in table 1 indicates the influence of different months of inarching on survival percentage of grafting at 75 DAG. The maximum survival percentage was recorded during the July (93.80%), followed by June (87.56%) and August (84.44%), while the minimum survival was observed in the month of January (56.57%). The decreasing trends of survival percentage was noticed towards the cooler month might be attributed to reduced rate of division of cambial cells, their differentiation and consequent development in healing of stock-scion union due to the decrease in the synthesis of endogenous auxins and mobilization of reserve food materials as result of reduced activity of hydrolysing enzymes. A decrease in activity of hydrolysing enzyme at low temperature has been reported by Nanda and Anand (1970) [21]. On the other hand, the highest survival of inarching in month of June-August might be attributed to optimum temperature and high humidity prevailed during this period, which resulted in successful union of cambium layers of stock and scion, early callus formation and initiation of subsequent growth (Gotur *et al*., 2017) [3]. Site of experiment *i.e.* Pantnagar district received maximum rainfall along with higher humidity and optimum temperature during the June-July, which might have developed conducive environment for graft success. Similar findings were also reported by Hartman and Kester (1979) [4], that temperature and relative humidity activates the cambial cells during monsoon. The callus tissue arising out of the cambial region is composed of thin walled turgid cells which can easily desiccated and die off and relative humidity can protect such cells in the cambial region of the graft union. These results are in close conformity with the findings of Naik (1952) [42] and (Rajan, 2011) [15].

In inarching, significant difference was observed in length of new growth due to the effect of time of grafting (Table 1). The highest length of new growth was recorded during July (8.55 cm) closely followed by August (7.65 cm) and June (7.44 cm) at 90 DAG. The minimum length of new growth was recorded in the month of January (4.99 cm) at 90 DAG. Possible reason for maximum growth in shoot length obtained in the month of June to August in the present study, might be due to the better production of assimilates for vegetative growth during this month and optimum temperature, sufficient sunlight, high relative humidity and ensured water availability, which had increased the rate of photosynthesis and led to the formation of more food materials that facilitated and improved the growth and development of the shoot. On the other hand, lowest growth of shoot length was recorded during December and January, which might be due to the higher temperature and lower humidity as well as severe winter in this month resulted in reduced growth rate of inarched plant. Similarly, Patil *et al*. (2009) [13] reported the maximum graft height (16.06 cm), when grafting was performed during the month of July in sapota.

Data in the table 1 revealed that the growth in terms of diameter was significantly influenced with the different dates of inarching. The highest increase in diameter of new growth was noted during the July (5.80 mm) closely followed by August (5.45 mm) and June (5.38 mm) at 90 DAG. Whereas minimum diameter of new growth was recorded in the month of February (4.29 mm) at 90 DAG. The following result may be due to favourable climactic parameters during monsoon helped in faster growths, which act positively on the rootstock and scion shoot, which might had happened due to the longer time available for growth in meristematic cells coupled with better physiological process such as photosynthesis and lower respiration (Muniyappan *et al.*, 2019) [8], higher photosynthetic activity leading to formation of more food material that facilitates the increase in girth of grafts. Our results are close to the finding of Ghojage *et al*., (2011) [2] in jamun, who recorded highest graft diameter (8.24 mm) from September grafts, while lowest (4.08 mm) in January grafts. Islam and Rahim (2010) [5] also reported maximum rootstock diameter (0.64 cm) in mango when grafting performed on 6th September.

Presented in the table 2 showed that, the highest number of primary branches was recorded during the July (3.47) closely followed by August (3.29) and June (2.99) at 90 DAG. Whereas, the minimum number of primary branches was recorded in the month of September (2.03) at 90 DAG. This might be also due to prevailing ideal temperature and relative humidity congenial for plant activity which had resulted in increased number of sprouts with more meristematic activity during August and early healing of graft union during this month. Further, also might be due to the presence of enough carbohydrate and other food material (as large scion is used) in the scion and rootstock and the accumulated food material is mobilized for new growth which in turns high meristematic activity in scion leads to higher number of branches (Muniyappan *et al.*, 2019) [8]. Patel *et al*. (2010) [12] reported higher number of sprout (3.11) when grafting was performed during July in "Khasi" mandarin.

Production of mean number of leaves was significantly affected by the time of operation (Table 2). The highest number of leaves was recorded during the month of July (9.37) closely followed by the month of August (9.08) and June (8.90) at 90 DAG, whereas, the minimum number of leaves was recorded in the month of January (6.72) at 90 DAG. The highest number of leaves might be due to the photosynthetic accumulation in newly grafted plants, which in turns increased the number of nodes and absorption of nodes and absorption of nutrients by leaf primordial. Water is one of the driving forces for cell elongation and multiplication and the grafting operation done during summer and early monsoon periods got the favourable soil moisture, humidity and temperature which showed favourable effect on number

of leaves on scion. These results are in accordance with those of Muniyappan *et al*., (2019) [8] and Sivudu *et al*. (2014) [20] in jamun and mango. This might be due to the development of more sprouts, more meristematic activity and better healing of grafts during these months. While the reason behind the poor vegetative growth in the month of January was mainly due to the plants less exposed to sun light as a result of cloudy weather and severe winter observed during this month, which adversely affected the photosynthesis in plants by stomata closing in mesophyll cells there by resulting in less vegetative growth. Mulla *et al*. (2011) also reported the highest number of leaves (12.48) in jamun grafts performed during the month of June.

Data in the table 2 indicates that the length of tap root was non-significant and it varied from 12.38 to 15.85 cm. On an average an increasing trends of tap root was recoded toward the cooler month. The highest increment in tap root was observed in the month of December (15.85 cm), whereas the lowest length was recorded during the May (12.38 cm) at 90 DAG. On the other hand, maximum increment in length of primary roots was recorded during the July (32.84 cm) closely followed by June (30.81 cm) at 90 DAG, whereas the lowest length of primary roots was noted in the month of March (19.71 cm) at 90 DAG (Table 3).

Data in the table 3 revealed that the highest fresh root: shoot ratio was recorded during the month of September and November (7.15) closely followed by the month of October (0.68) at 90 DAG. Whereas, the lowest roots: shoot ratio was recorded in the month of June (0.56) at 90 DAG. On the other hand, the highest dry root: shoot ratio was recorded during the month of July (0.71) closely followed by month of June (0.69) at 90 DAG. Whereas, lowest dry roots: shoot ratio was observed in the month of February (0.48) at 90 DAG. The highest dry root: shoot ratio was noted during the month of June to July, which might be attributed to availability of scions with active buds, the proper physiological condition of the rootstock, increased sap flow, congenial environmental conditions owing to rapid callusing and early contact of cambial layers, thus enabling the grafts to heal quickly and make a strong union, which leads to better production of vegetative growth as well as root growth (Langpoklakpam *et at*., 2017) [6].

Table 1: Effect of different time of inarching on the survival percentage at 75 DAG and length and diameter of new growth at 90 DAG.

Treatments	Survival percentage (%)	Length of new (cm)	Diameter of new (mm)
February'18	57.30	5.21	4.29
March'18	62.55	5.71	4.46
April'18	71.91	6.05	4.73
May'18	72.24	6.85	4.88
June'18	87.56	7.44	5.38
July'18	93.80	8.55	5.80
August'18	84.44	7.65	5.45
September'18	75.26	6.67	5.16
October'18	68.80	5.60	4.48
November'18	65.92	5.35	4.55
December'18	66.35	5.08	4.38
January'19	56.57	4.99	4.30
C.D.	0.54	0.16	0.12
SE(m)	0.18	0.06	0.04

Table 2: Effect of different time of inarching on the number of primary branches, number of leaves and length of tap root at 90 DAG.

Treatments	No. of primary branches	No. of leaves	Length of tap roots (cm)
February'18	2.62	7.53	13.33
March'18	2.38	7.74	13.51
April'18	2.54	8.08	13.14
May'18	2.66	8.44	12.38
June'18	3.29	8.90	12.43
July'18	3.47	9.37	14.36
August'18	2.99	9.08	14.15
September'18	2.03	8.31	14.58
October'18	2.63	7.73	13.83
November'18	2.59	7.28	15.01
December'18	2.57	6.85	15.85
January'19	2.25	6.72	14.98
C.D.	0.31	0.25	NS
SE(m)	0.11	0.09	0.86

Table 3: Effect of different time of inarching on the length of primary roots, fresh and dry root: shoot ratio at 90 DAG.

Treatments	Length of primary roots (cm)	Root: shoot ratio (fresh)	Root: shoot ratio (dry)
February'18	25.72	0.63	0.48
March'18	19.72	0.59	0.55
April'18	22.04	0.60	0.50
May'18	24.09	0.58	0.50
June'18	30.82	0.56	0.68
July'18	32.84	0.61	0.70
August'18	28.42	0.62	0.57
September'18	28.74	0.72	0.55
October'18	25.67	0.69	0.49
November'18	27.92	0.72	0.62
December'18	24.04	0.66	0.53
January'19	29.84	0.57	0.51
C.D.	3.44	0.03	0.05
SE(m)	1.19	0.01	0.02

Conclusion

From the present finding, it can be concluded that under *tarai* conditions of Uttarakhand inarching performed during the month of June- August is the most suitable time for quality production of jackfruit plants of cv. Pant Garima. As at this time the survival percentage and subsequent growth of grafts is relatively better than the other months.

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