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Standardization of Vegetative Propagation Methods for Tamarind (*Tamarindus indica* L.) under Kerala Conditions

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Abstract

Tamarind is an underutilized crop known for its climate resilience. The state of Kerala is known for its rich diversity of local and wild tamarind trees. However, there is no standardized vegetative propagation method that is practiced locally in the state. Hence, to produce vegetative propagules of tamarind plants for conservation of local elite trees and to meet demands of homestead gardeners and farmers, five different vegetative propagation methods were evaluated in four different seasons (March, June, September and December) of a year. Amongst the different treatment combinations studied, veneer grafting showed highest success (70%) during March, which was on par with softwood grafting (65%) and approach grafting (60%) methods. Mean of all the grafts prepared in March showed highest shoot length (6.91 cm). Correlation study showed a significant association of mean maximum temperature with graft success rate (r=0.97). Hence, veneer grafting or softwood grafting methods could be recommended for tamarind propagation during March in order to get maximum saleable plants. This would be helpful in conservation of elite local genotypes as well.

Key words: *Humid climate; seasons; softwood grafting; veneer grafting*

Introduction

Tamarind is a multipurpose species, which is known for its drought tolerance and has become popular in most of the tropical and subtropical countries due to its variety of industrial and non-industrial uses (El-Siddig et al., 2006). In India, it is mainly distributed in warm and drier tropics and subtropics with an area of 48,000 ha. In Kerala, tamarind is being distributed on an area of 10,610 ha with an average annual production of 36,470 Mt (Indiastat, 2022). The major districts of Kerala in terms of tamarind production are Palakkad, Thiruvananthapuram, Malappuram, Kozhikode and Thrissur. Landraces such as Valanpuli, Thenpuli and Madhurapuli are popular amongst the people of Kerala. In most households of the country, tamarind is being widely used as a souring agent in indigenous cuisines. Even though Kerala is one of the largest tamarind producing states of India, majority of tamarind grafts for planting are currently being procured directly from nurseries of adjacent Tamil Nadu state or through local nurserymen who procure grafts from Tamil Nadu based on prior orders.

Since long, tamarind has been one of the major components of homestead gardens. But, due to the fragmentations of land and population pressure, homestead gardens are facing severe threat and at the verge of losing many tree components including tamarind. The area under tamarind in Kerala has seen a drastic reduction of 25% and 42% in 2017-18 compared to 2008-09 and 1997-98, respectively (Indiastat, 2022). Being perennial, tamarind seedling trees take about 8-12 years for bearing fruits whereas grafted/ budded plants are reported to yield in 3-4 years after planting (Farooqi et al., 2005).

The climate pattern of Kerala has drastically changed over the past few decades and frequency of droughts has increased considerably (Abhilash et al., 2019). So, integration of climate-resilient crops like tamarind could ensure sustainability and farm income to the farmers. Hence, to reintroduce tamarind in existing cropping systems like homestead gardens and to provide quality planting material in bulk for commercial cultivation and germplasm conservation, efficient vegetative propagation method and season needs to be standardised. There is hardly any scientific literature available on tamarind propagation in Kerala and hot humid climatic regions, and hence the present study was undertaken to identify the best propagation method in hot and humid climatic region of Kerala.

Materials and Methods

The present study was conducted at the Department of Plantation crops and spices, College of Horticulture, Kerala Agricultural University (KAU), Thrissur during the year 2017 to 2019. The study area is located at 10°32'58.3"N 76°17'02.4"E with an elevation of 30 m. The area receives an annual rainfall of about 2,500 mm from the rains of both South West and North-East monsoons. The experiment was designed using Factorial CRD with five propagation treatments (veneer grafting, wedge grafting, approach grafting, patch budding, air layering) and four seasons [March (summer), June (monsoon), September (post-monsoon), December (winter)]. Each treatment was conducted with four replications with 40 plants per treatment per season.

For grafting and budding, one-year-old local tamarind seedlings of uniform growth and pencil thickness were used as rootstocks. Scion sticks of 10-12 cm with 6-8 buds were used for softwood grafting and veneer grafting; whereas, single bud taken from scion stick was used for patch budding. Scion shoots were collected from a selected elite tree present in the main campus of KAU. Scion shoots were defoliated just before grafting in all seasons except during summer when naturally defoliated shoots were available on the trees. Air layering was done by girdling the pencil thick shoots at 20 cm from the tip. Girdled ends were treated with indole-3 butyric acid (IBA) 1,000 ppm, wrapped with wet moss and covered with polythene cover. Approach grafting was performed on the same elite tree. Observations were recorded for the time taken by the grafts to sprout, success percentage at 30 days after grafting (DAG), shoot length at 60 DAG, number of branches per graft at 90 DAG and final success percentage at 90 DAG. Statistical analysis and correlation studies were carried out using IBM- SPSS STATISTICS 22 and WASP 2.0 software.

Results and Discussion

Time taken for sprouting is an important parameter with respect to success of grafting and its establishment. Significant difference was observed in the time taken for sprouting among grafting and budding methods (Table 1). Time taken for sprouting was lesser for softwood grafting (4.5 days) followed by veneer grafting (9.3 days). Patch budded plants failed to sprout in all the seasons and hence, they were excluded from further statistical analysis. Time taken for sprouting among four seasons was comparatively more during September. Softwood grafts took least days (4.5 days) to sprout during March, whereas veneer grafts took least days to sprout during June. The temperature of 32 °C has been reported to favour callusing in apple grafts resulting in successful graft union; however, temperature above 32°C causes injury and beyond 40°C tissue death could occur (Shippy, 1930). Higher temperature prevailing during the March might be the reason for early sprouting and faster establishment of vascular connection across the graft union due to quick cell multiplication and growth (Agasimani et al., 2019).

Table 1. Performance of different propagation methods in tamarind

	*Time taken for sprouting (days)	*Success (%) at 30 days	*Shoot length at 60 days	Success (%) at 90 days	*No. of branches at 90 days
SEASON					
S_1-March	6.15	73.75	6.91	51.25	4.72
S_2-June	6.63	0.00	0.00	1.88	0.00
S_3-Sept	8.19	0.00	0.00	10.00	0.00
S_4-Dec	6.65	7.50	4.46	16.88	1.06
METHOD					
P_1-Air layering	-	-	-	16.88	-
P_2-Approach grafting	-	-	-	25.63	-
P_3-Softwood grafting	4.50	17.50	1.82	16.25	1.248
P_4-Veneer grafting	9.30	23.13	3.87	21.25	1.643
INTERACTION					
S_1P_1	-		-	10.00	-
S_1P_2	-		-	60.00	-
S_1P_3	3.33	70.00	7.26	65.00	4.99
S_1P_4	8.98	77.50	6.55	70.00	4.45
S_2P_1	-		-	0.00	-
S_2P_2	-		-	7.50	-
S_2P_3	5.38	0.00	0.00	0.00	0.00
S_2P_4	7.88	0.00	0.00	0.00	0.00
S_3P_1	-		-	30.00	-
S_3P_2	-		-	10.00	-
S_3P_3	4.88	0.00	0.00	0.00	0.00
S_3P_4	11.50	0.00	0.00	0.00	0.00
S_4P_1	-		-	27.50	-
S_4P_2	-		-	25.00	-
S_4P_3	4.43	0.00	0.00	0.00	0.00
S_4P_4	8.86	15.00	8.93	15.00	2.13
CD					
Season (S)	**NS**	**7.26**	**2.50**	**5.50**	**0.69**
Propagation method (P)	**1.55**	**5.14**	**1.77**	**5.50**	**NS**
Factor (S × P)	**NS**	**NS**	**3.54**	**10.99**	**0.97**

*Observations and statistical analysis were carried only for detached method of grafting (softwood grafting and veneer grafting).

NS – non significant, S – season, P – propagation method

The tamarind softwood grafts took 24 to 27 days to sprout during March, April and May months and complete mortality was observed in grafts prepared during December, January and February. Time taken for bud sprouting is known to get affected as the temperature starts rising and humidity starts dropping

(Singh and Srivastava, 1962). Two independent studies from Chhattisgarh and Tamil Nadu reported that bud breaking in tamarind softwood grafted plants took 9 to 17 DAG (Anil et. al., 2022; Mayavel et. al., 2022). In the present study, it was observed that time taken to sprout was lesser with increasing temperature, which might be due to higher relative humidity at this region. Softwood grafting in tamarind between the period of leaf fall and new growth was found to be best in Rahuri condition, which was quite opposite to normal propagation season of major tropical crops like mango and sapota (Lalaji, 2001). Hence, the present study is in agreement with the earlier reports (Singh and Srivastava, 1962; Lalaji, 2001; Mayavel et. al., 2022).

Patch budding completely failed during the experiment as there was no sprouting even after 3 months of budding, probably due to nonunion of cambial cells of scions and rootstock. Prominent observation in this study was that most of the veneer and softwood grafts sprouted within 3-5 days as compared to other regions where it generally took 20 to 35 days to sprout (Singh and Singh, 2007). In the present study, early sprouting of scion might have been accelerated due to combined effect of high temperature and high humidity inside the mist house which led to the sprouting of scion at the expense of reserved food in its tissues without the proper cambial union. This led to exhaustion of scion making it difficult for further growth after the union and subsequent drying up of sprouts before reaching even a minimum length of 2 cm. Unlike scion stick used in grafting, bud patch lacks good food reserves, which might have resulted in failure of patch budding.

Success percentage after 30 days grafting is an indicator for early estimation of grafting efficiency. There was a significant difference among the seasons and propagation methods for establishment success percentage (Table 1). Irrespective of the propagation methods followed, the highest success rate (73.75%) was recorded in March. Sprouting was observed initially in the grafts prepared during June and September but complete mortality was noticed within 30 days of grafting. Veneer grafting was recorded with the highest success rate (23.13%).

Length of the shoot at 60 days after grafting is another parameter for assessing the vigour of the grafted plant and ensuring proper contact between the scion and the stock. The differences in shoot length amongst different propagation methods were highly significant (Table 1). Maximum shoot length was recorded by veneer grafting (3.87 cm) whereas softwood grafting recorded lowest (1.82 cm). Grafts prepared in March season recorded highest shoot length (6.91 cm) which was on par with shoot length of December grafts (4.46 cm). There was no success in veneer grafting (produced during June and September) and softwood grafting (produced during June, September and December).

Shoot length is significantly and negatively correlated with number of branches present in the graft (Table 2). The influence of interaction effect of season and propagation method on shoot length was highly significant. Maximum shoot length was recorded for veneer grafting carried out during December (8.93 cm). This might be due to lesser branches per graft as a result of less sprouting of buds during winter. This was on par with shoot lengths of softwood grafts produced during March (7.26 cm) and veneer grafts prepared during March (6.55 cm).

Table 2. Correlation between length of the shoot and number of branches

	Length of shoot	Number of branches
Length of shoot	1	
Number of branches	-0.61*	1

* significant at 0.05 level.

Number of branches per graft at 90 days after grafting expresses the proper union of graft, health of scion and plant vigour. The differences in number of branches were not significantly influenced by method of grafting (Table 1). Observations were recorded only for detached method of grafting. Number of branches remained statistically similar between veneer grafting (1.64) and softwood grafting (1.25). Season of grafting had significant influence on number of branches. Overall, March season grafts recorded highest number of branches (4.72) which might be due to higher temperature and more active bud sprout in March. Contrastingly, least number of branches was observed in December grafts (1.06) which might be due to unavailability of good quality scion wood as the tree normally remains in fruit development stage. Less bud sprouting during this season might be due to lower temperature.

Influence of interaction of season of grafting and propagation method was highly significant with respect to number of branches. Softwood grafts produced during March recorded maximum number of branches (4.99) which was statistically on par with those produced by veneer grafts prepared during the same season (4.45). Lowest number of branches was recorded by veneer grafts prepared during December (2.13). Lower temperature and scion in the active growth stage are responsible for reduction in number of branches in December whereas in March, all the buds on scions are dormant and high temperature coupled with high humidity enhanced sprouting of more buds to form branches.

Successful establishment after three months of grafting/layering represents the saleable plants those are suitable for transplanting after another three months. The differences in rate of success among the seasons were highly significant. Overall highest success was obtained in propagules produced during March month (51.25%), irrespective of propagation methods.

Among the different treatment combinations, veneer grafting recorded highest success (70.00%) during March, which was on par with softwood grafting (65.00%) and approach grafting (60.00%) prepared during the same period. The union was not successful in softwood grafts prepared during June, September and December even after normal sprouting of scion. Similarly, in case of veneer grafts produced during June and September, the success was nil. Air layers produced during June recorded zero establishment percentage even though there was successful rooting observed. In Air layering, layers produced during September recorded maximum survival (30.00%) followed by December (27.50%) and March (10.00%). Season dependent success in air layering has been previously reported in tropical species such as *Spondias pinnata* and *Cinnamomum verum* (Tomar, 2016; Waman and Bohra, 2018). Among the approach grafts, grafts prepared during March recorded highest survival (60.00%) followed by grafting during December (25.00%) and September (10.00%).

In a study conducted at Andhra Pradesh on grafting of tamarind, 68% and 49% success were observed in softwood grafts and veneer grafts, respectively during April (Purushotham and Narasimharao, 1990). In a similar study from Chhattisgarh, tamarind softwood grafts recorded highest success of 63% to 80% during March month (Anil et al., 2022). Higher success percentage during March, April and May months might be due to the favourable environment with optimum temperature and relative humidity. This might have enhanced the union of the scion and stock cambial layers coupled with precocious callus formation and development of good vascular network between stock and scion (Hartmann et al., 2010; Agasmani et al., 2019; Praveenakumar et al., 2019; Umadevi et al., 2021) as also observed in the present study.

The studies in jackfruit conducted under Tarai conditions of Uttarakhand reported wedge grafting as the best propagation method to be performed from December to April (best in March) (Rai et al., 2021). Among temperate trees (e.g. apple, pear), when dormant scions were used for grafting on active rootstocks, the graft success percentage was found to be higher (Leakey, 2014). Similar result was obtained in this study during March, when naturally defoliated scions were used for grafting and significantly higher success percentage was obtained.

The present study revealed that patch budding was not a reliable technique for tamarind propagation in this region as also noticed in Godhra region of Gujarat (Singh and Singh, 2007). Probable causes for failure of union could be non-optimal temperature during cell division and formation of union, loss of cell turgidity due to desiccation of scion, physical movement in the junction of scion and rootstock and microbial infection (Hartmann et al., 2010). In the present study, grafts prepared during June, September and December failed to survive even after 100.00% sprouting within 15 days in all the seasons.

Understanding of season and weather is essential for ensuring success of propagation. Graft callus formation and healing are highly influenced by environmental factors such as temperature, relative humidity and grafting season (Hartmann et al., 2010). Correlation of weather parameters with the final success percentage revealed interesting results. The maximum success in veneer grafting, softwood grafting and approach grafting were obtained, when the monthly mean maximum temperature ranged between 33 and 37 °C (Fig. 1). Success was nil in the months, when mean maximum temperature dropped below 32.9 °C. Correlation studies revealed that maximum temperature was the most influencing parameter (r=0.97*) for overall success of propagation, irrespective of propagation methods studied (Table 3).

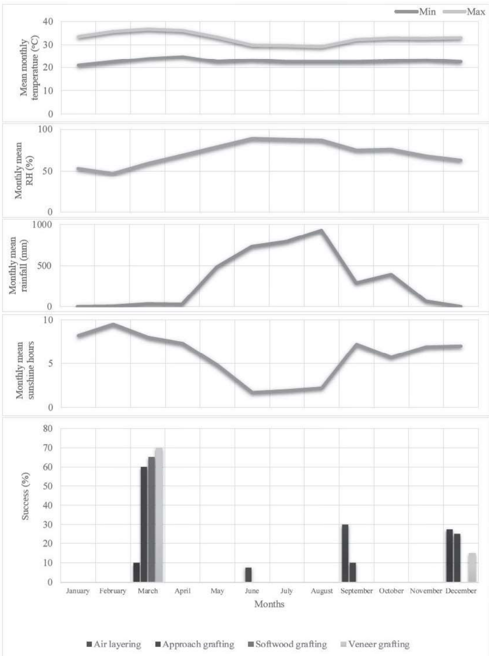

Fig. 1. Influence of weather parameters on graft success

Table 3. Correlation between weather parameters and final success percentage at 90 days after grafting.

	Min. Temperature (°C)	Max Temperature (°C)	RH (%)	Rainfall (mm)	Sunshine (hours)	Final graft success
Min. Temperature (°C)	1					
Max Temperature (°C)	0.70	1				
RH (%)	-0.19	-0.81	1			
Rainfall (mm)	-0.23	-0.84	1.00**	1		
Sunshine (hours)	0.26	0.86	-0.90	-0.93	1	
Final graft success	0.84	**0.97***	-0.68	-0.72	0.73	1

* significant at 0.05 level.

** significant at 0.01 level.

The softwood and veneer grafts showed success in the months having average relative humidity of 60-65% (Fig. 1) with zero precipitation, whereas approach grafting recorded maximum success of 25 to 60% during zero precipitation month and it was as low as 7.5 to 10% during months with 290 to 790 mm rainfall.

Higher rainfall of above 500 mm per month with heavy downpour in short period caused complete leaf fall of the air layers and approach grafted plants along with complete leaf fall of mother trees. Trees recovered after heavy rains by putting forth new flush, but the air layered and approach grafted shoots along with rootstocks failed to recover after heavy rains receded, which led to higher mortality of grafts and layers prepared during the present study. Higher success in the grafts appears to be slightly associated with longer sunshine hours, generally in the range of 7-10 h.

In a similar study under Dharwad region of Karnataka, the lowest success (12.03%) was observed in December whereas highest success (48.16%) during January followed by February (38.79%) in softwood grafting (Kumar et al., 2003). They reported that relative humidity of 60-65% coupled with maximum and minimum temperature of 34.0 °C and 16.7 °C, respectively after December month favoured higher grafting success in January and February. These factors might have accelerated cell activity and quick union of cambium across juxtaposed regions. The lower rate of graft success in December might be due to drop in temperature. In Rahuri region of Maharashtra, grafts prepared during December to March failed to sprout probably due to low minimum temperature (6.3 to 11.0 °C) and low relative humidity (around 30%) during the period (Lalaji, 2001), which reduced cell division rate and callus formation across the union. They also obtained very less success during September which was reported to be due to unavailability of good bud woods as the tree was in pod development stage.

Conclusion

From the present study, it is evident that ideal season for propagation of tamarind is March under Kerala conditions, which coincides with the period between leaf fall and new flushing. Significant differences were noticed in different seasons and the highest survival was obtained in March with veneer grafting followed by softwood grafting. Based on the results, air layering, approach grafting and patch budding methods were not recommended for tamarind propagation in the region. The maximum temperature and relative humidity were identified as key parameters that influence the success percentage of grafts. The results would help in taking up mass multiplication activities of elite genotypes of tamarind in the region.

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