# Clonal Multiplication of Healthy Planting Material for Successful Establishment of Orchards under Changing Climate of Coastal Maharashtra

**P. C. Haldavnekar[1], M. M. Kulkarni[2], S. G. Ragji[3], O. A. Lad[3], A. P. Jadhav[3], V. V. Padge[3], D. T. Kolekar[2], C. D. Pawar[2], B. R. Salvi[2], R. G. Khandekar[2], N. V. Dalvi[2], K. V. Malshe[4], P. M. Haldankar[5], M. G. Nayak[6], P. Patil[7], D. D. Nagvekar[8], R. T. Gunjate[9], M. M. Burondkar[3], M. S. Joshi[3], V. S. Desai[10] and S. A. Chavan[3]**

[1]DBSKKV-College of Horticulture, Mulde, Sindhudurg, Maharashtra - 416520 (India)
[2]DBSKKV-College of Horticulture, Dapoli, Ratnagiri, Maharashtra - 415712 (India)
[3]DBSKKV-College of Agriculture, Dapoli, Ratnagiri, Maharashtra - 415712 (India)
[4]DBSKKV-Mango Research Sub-station, Girye, Devgad, Sindhudurg, Maharashtra - 416806 (India)
[5]Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra - 415712 (India)
[6]ICAR-Directorate of Cashew Research, Puttur, Dakshin Kannada, Karnataka - 674202 (India)
[7]Indian Institute of Horticulture Research, Bengaluru, Karnataka - 560089 (India)
[8]DBSKKV-Coconut Research Station, Bhatye, Ratnagiri, Maharashtra - 415612 (India)
[9]Reliance Industries, Agriculture Division, Jamnagar, Gujarat (India)
[10]DBSKKV-Regional Fruit Research Station, Vengurle, Sindhudurg, Maharashtra - 416516 (India)

**Abstract**

**Konkan region of Maharashtra has rich bio-diversity of various horticultural crops including of fruits, plantation crops and tree spices. The recent fluctuations in climatic conditions are affecting establishment as well as performance of the new plants. Use of healthy planting material result in development of healthy canopy capable of sustaining the climatic vagaries. Protocols are developed for rapid clonal multiplication of various fruits, plantation crops and tree spices in coastal region. Epicotyl and softwood grafting in mango, kokum, karonda, sapota, aonla, cashew, air layering in cinnamon and cuttings in black pepper exhibit greater success and also produce healthy planting material capable of achieving vigorous growth which lead to better establishment of plants in the field.**

**Key words:** Clonal propagation, epicotyl grafting, soft wood grafting, air layering.

## Introduction

Konkan region of Maharashtra has rich diversity of various tropical fruits cultivated both commercially as well as in homesteads. Most of these fruit crops are heterozygous in nature due to cross pollination and does not produce true to type plants when propagated through seeds. Kokum and nutmeg are dioecious and may produce around 50 per cent male plants. The seedling progenies grow tall and are not effective in high density planting systems. Moreover the prebearing age of seedling progenies is long as compared to clonal progenies and is seldom preferred in commercial plantations. Hence, development of vegetative propagation methods in various horticultural crops carries immense importance. Coastal region has warm and humid climatic conditions which are conducive for propagation of various fruits as well as plantation crops. In recent years the region is experiencing significant variation in weather parameters like sudden increase in weather temperature, prolonged cold wave, increase in rainfall, unseasonal rains especially during January to April which not only alter the phenophases of fruit crops altering production cycle but also aggravate the incidence of several pests and diseases (Prasanta 2007). Such aberrant changes also effect the establishment as well as further vegetative growth of healthy planted orchards. Only healthy planting material can sustain such calamitous situation and continues their growth in developing healthy canopy. Such new grown healthy plants in orchard can sustain in climatic vagaries and produces quality yield. The protocol for production of healthy planting material profuse root system in mango has been developed especially for the planting in lateritic rocks. As the Konkan region is hilly and characterised

**Corresponding author**: pchdapoli@yahoo.co.in
*Received Date: 4.10.2019; Accepted Date: 12.12.2019.*

with well drained porous soils, the availability of water for irrigation is scare. The technology of *in situ* grafting has been developed for establishment of horticulture plantations in water scarcity areas. Several such technologies have been developed in various fruit, plantation and tree spices which are responsible in area expansion under various horticultural crops especially in coastal region of Maharashtra.

**Clonal propagation**

***Hard wood cutting*:** The propagation by hard wood cutting is an age old practice used mostly in woody perennials including fruit crops, which is one of the cheapest and easiest methods and still hold good in fruit crops for raising of rootstock. July and August are the best months for hard wood cuttings in karonda for better survival. Greater length of hard wood cuttings of 35 cm helped to obtain better success (66.66%) than smaller length of 21 cm (44.99%). The performance of hard wood cuttings under mist conditions was superior (Divekar 2011). Use of Indol Butaric Acid (1000 ppm to 3000 ppm) improved the success percentage, number of root and root length**.** The karonda cuttings planted in July and August gave maximum rooting (50%) and number of roots per cutting (10.50) (Divekar 2011). The treatment of karonda cuttings with IBA at 2000 and 3000 ppm concentration under mist proved to be the best treatment for rooting (53.33%). The presence of leaves on karonda cuttings under mist gave maximum rooting and induced more number of roots. IBA 3000 ppm with sand propagation media was the best treatment combination for rooting (47.33%) and vegetative growth of hardwood cuttings of Karonda under 90 per cent (49.11 % survival) and 60 per cent (38.22 % survival) relative humidity in green house condition (Nimbalkar *et al.* 2011)

***Budding*:** In fruit crops viz., jackfruit among the various methods of budding patch, forket and 'I' budding methods were appropriate. All these methods resulted for maximum number of leaves and length of sprout in the month of February on nine month old rootstock (Kelaskar 1988). The budded plants of jackfruit can be prepared on any type of rootstock belong to *Artocarpus heterophyllus* with or without leaf retention on it. Uses of bigger size polybag (25 x 30 cm) improved the vigour of budded plants (Kelaskar 1988).

***Inarch grafting***: Inarching often called as approach grafting is useful in species which are difficult to propagate by other methods of grafting. It is an ancient and commercial method adopted for mango and sapota. Rootstock raised in polybag is grafted on desired scion by tying the bag on the tree. Rootstock of different age from three weeks to three years can be used for inarch grafting. Although, inarch grafting gives better success, the method is costly, cumbersome, requires larger bud wood and long time to produce successful grafts. Further limited numbers of grafts are prepared and interfere with intercultural practices.

The best success (53.33 to 80%) was observed in Kokum during the months from January to April and August to December under Konkan agro climatic conditions (de Andrade 1983). Similarly in Jamun, sprouting (90.49%) and survival (71.31%) were the highest in the approach grafts prepared during October month (Hande 1987).

***Veneer grafting*:** Veneer grafting is a form of side grafting, first recommended by Lynch in Florida (Lynch 1941). In India, this method was tested extensively by Mukharjee and Mujumdar (1961). This method was popularised as *in-situ* in areas to convert country seedlings in superior quality varieties. Veneer grafting in mango was tried by most of the scientists to overcome the drawbacks of inarch grafting.

Veneer grafting method was tried first by Uradya in mango under Konkan conditions (Gunjate and Limaye 1978). It was successful during the period from March to first fortnight of May (76 to 84%) (Gunjate and Limaye 1978). Grafts prepared during March to May were available for planting in the field during the monsoon of the same year. Success in sprouting of veneer grafts (76 % to 92%) was related with age of scion stick (1½ to 6½ month). Scion selected from younger trees having age of 32 to 35 year resulted in higher success (88%). Defoliation of scion stick did not show any significant results. Hence, it is not necessary to defoliate scion in Alphonso mango under Konkan agro climatic conditions (Gunjate *et al.* 1976).

Age of rootstock plays a vital role in success of graft. Use of 14 months old rootstock resulted in highest success in sprouting and vigour of graft. Scion stick grafted on same day of harvest showed better performance. Scion stick stored in sphagnum moss followed by wrapping in moist newspaper or alkathene sheet at room temperature for 10 days showed better sprouting success (73.33 %) in the month of May. It was the better indication for storage of scion and transporting it to another place for grafting for nursery industry (Gunjate *et al.* 1976).

During rainy season, use of 250 gauge alkathene tape resulted in 51.33 % sprouting success and was suitable (Gunjate *et al.* 1976). During summer months, less

success was obtained when grafts were raised in shade (68.66%) as compared to open condition (76.66%) (Gunjate *et al.* 1976). High percentage of survival (73.33%) was obtained from an unskilled labour (Gunjate *et al.* 1976).

Re grafting on failed grafts was slightly low (68%) than fresh rootstock (72%) (Gunjate *et al.* 1976).Veneer grafting which in mango confined to a short period for the scion stick availability restricted during March to April (Gunjate *et al.* 1976) the success was improved by using container raised seedlings (Gunjate and Limaye 1978, Gunjate *et al.* 1976).

Veneer grafting was a success during November to April (80 to 93.33%) in kokum, September and December (40%) in cashew and mid-April and November (60%) in jackfruit (de Andrade 1983, Harnekar 1980, Kolekar 1979).

***Epicotyl grafting*:** It is simple, easy and rapid commercial method followed in mango, jackfruit and other fruit crops.

The modified wedge technique had better success (69%) whereas poor success (47%) was obtained by veneer grafting (Dengale 1980). Stone grafting gave significantly maximum grafts (49.73%) from a given number of seedlings followed by veneer grafting (45.67%) and inarching (35%) (Kotecha 1982). Humidity and minimum temperature govern the success of stone grafting (Kotecha 1982). The best season for stone grafting in mango under the coastal condition is from June to September with 62 to 65% success (Gunjate *et al.* 1982, Nagwekar *et al.* 1984). The better availability of moisture might have kept the cells more turgid leading to rapid proliferation of callus and quicker healing of graft union during mansoon (Dabhole 2012). The success in stone grafting vary according to varieties which was 86, 85, 70, 69, 66, 65 and 64% in Kesar, Totapuri, Pairi, Alphonso, Vanraj, Fernandin, and Goamankur respectively (Gawankar *et al.* 2010). No appreciable effect of rootstocks of different varieties on success of stone grafting was noticed. In India, mango is commercially grafted on non descript seedling rootstock.

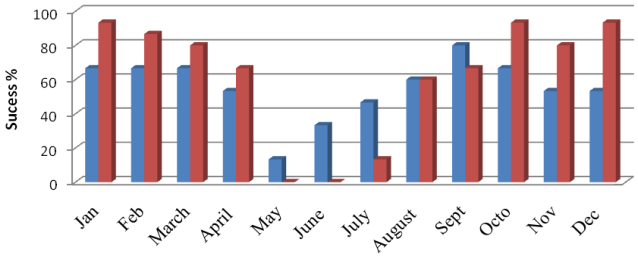


**Fig. 1.** Effect of season on success in inarch grafting in kokum and jamun

**Table 1.** Effect of season on sprouting of different bud grafts of jackfruits.

| Treatment | Shield budding | Inv T budding | Patch budding | Forkert budding | I budding | Chip budding | Ring budding | Flute budding |
|---|---|---|---|---|---|---|---|---|
| April 1987 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May 1987 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| June1987 | 0 | 0 | 23.83 | 0 | 15.00 | 0 | 0 | 0 |
| July 1987 | 0 | 0 | 28.66 | 0 | 15.00 | 0 | 0 | 0 |
| Aug 1987 | 0 | 0 | 33.33 | 25.00 | 26.66 | 0 | 0 | 0 |
| Sep 1987 | 0 | 0 | 50.00 | 33.33 | 31.66 | 0 | 0 | 0 |
| Oct 1987 | 0 | 0 | 45.00 | 43.33 | 35.00 | 0 | 0 | 0 |
| Nov 1987 | 0 | 0 | 60.00 | 45.00 | 45.00 | 0 | 0 | 0 |
| Dec 1987 | 0 | 0 | 63.33 | 48.33 | 48.33 | 0 | 0 | 0 |
| Jan 1988 | 0 | 0 | 66.66 | 63.33 | 55.00 | 0 | 0 | 0 |
| Feb 1988 | 0 | 0 | 71.66 | 66.66 | 58.33 | 0 | 0 | 0 |
| March 1988 | 0 | 0 | 46.66 | 50.00 | 33.33 | 0 | 0 | 0 |
| F test | | | Sig | Sig | Sig | | | |
| SE± | | | 2.73 | 2.17 | 3.34 | | | |
| CD @ 5% | | | 8.00 | 6.36 | 9.79 | | | |

(Figures in parentheses indicate Arcsine transformed values). Source**:** Kelaskar 1988.

**Table 2.** Effect of season on success in various grafting methods in Mango.

| Method | Period | % Success |
|---|---|---|
| Veneer grafting | October | 92.00 |
| | November | 76.00 |
| | December | 84.00 |
| | February | 76.00 |
| | March | 92.00 |
| Softwood grafting | January | 60.00 |
| | February | 58.00 |
| | March | 60.00 |
| | April | 68.00 |
| | May | 72.00 |
| | June | 54.00 |
| | September | 66.00 |
| | October | 82.00 |
| | November | 70.00 |
| | December | 68.00 |
| Stone grafting | June | 61.00 |
| | July | 58.50 |
| | August | 70.00 |
| | September | 61.30 |
| | October | 49.30 |
| | November | 35.00 |
| Stone grafting | June | 78.25 |
| | July | 44.40 |
| | August | 24.60 |
| Stone grafting | June | 64.90 |
| | July | 64.90 |
| | August | 62.20 |
| | September | 62.20 |
| | October | 55.00 |
| | November | 35.90 |
| Stone grafting | June | 58.5 |
| | July | 65.00 |
| | August | 65.75 |

Source**:** Harnekar 1980, Desai and Desai 1989, Dengale 1980, Kotecha 1982, Gunjate *et al.* 1982, Nagwekar *et al.* 1984.

Efforts were made to screen different rootstocks for various scion varieties as the results on the use of mono embryonic and poly embryonic rootstocks were inconsistent (Gawankar *et al.* 2010).

The rootstock less than two weeks of age with coppery-red colour was more suitable for better sprouting success (73.3%) and further scion growth (Dengale 1980) and the success in stone grafting enhanced with increase in age of scion shoot (Gunjate *et al.* 1982). The survival of stone grafts prepared with sub terminal scion shoots (63%) of 10-15 cm in length without procuring was greater compared to terminal scion shoots (60.66 %) (Kotecha 1982, Gunjate *et al.* 1982, Nagwekar *et al.* 1984).

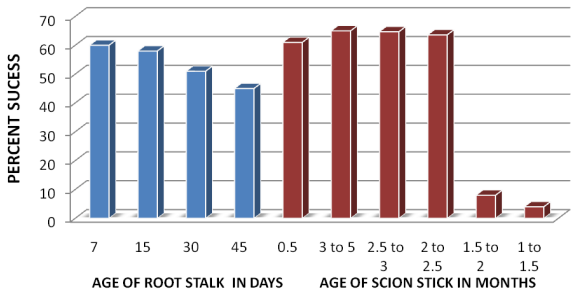


**Fig. 2.** Effect of age of rootstock and age of scion on success (%) of epicotyl grafting in mango.

The scion sticks could be stored only for 4 days without much loss of success in stone grafting (46.66% - 52.30 %) (Dengale 1980, Nagwekar *et al.* 1984) Dipping cut ends of scion sticks in melted paraffin wax and storage in sealed polythene bags helped to extend its use (Kotecha 1982). The short viability of mango stones up to 93 days is the limitation in extending the period of stone grafting. However Polythene bag along with charcoal and vermiculite was the best media for storing stones for longer period without losing its viability (Patil *et al.* 1986).The rootstock vigour was closely related to the weight of seed and large sized stones had maximum (85 %) germination for stone grafting (Patil *et al.* 1986). Mango seeds collected from mango canning industry had 75 % germination (Patil *et al.* 1986). Mango stones treated with Gibberellic acid at 500 and 1000 ppm resulted in maximum germination i.e.76 % and 72 %, respectively with highest number of graftable seedlings (Patil *et al.* 1986).

The potting mixtures of soil + FYM (3:1) was the best for stone grafting which gave significantly the highest survival (76 %) and remarkable growth of stone grafts in coastal conditions (Nagwekar *et al.*1984).

Grafting on rootstock raised directly in polythene bags without disturbing root system had better success (65.42 %- 70 %) than uprooted seedlings as rootstocks (52 %-56 %) (Patil *et al.* 1986). In *situ* grafting gave enhanced

**Table 3.** Growth and yield of different mango varieties grafted on Vellaikolamban and mixed rootstock

| Treatment | Mean height (m) | Avg. Plant Volume ($m^2$) | % reduction in volume | Yield (t $ha^{-1}$) | % decrease /increase in yield over mixed rootstock |
|---|---|---|---|---|---|
| Ratna / Vellai Kolamban | 3.6 | 285.9 | 24.9 | 5.9 | (-) 24.4 |
| Ratna / Mixed rootstock | 3.7 | 380.8 | - | 7.8 | - |
| Alphonso / Vellai Kolamban | 3.8 | 323.5 | 39.1 | 2.9 | (-) 21.6 |
| Alphonso / Mixed rootstock | 4.7 | 531.3 | - | 3.7 | - |
| Kesar / Vellai Kolamban | 4.6 | 478.8 | 26.5 | 8.6 | (+) 10.3 |
| Kesar / Mixed rootstock | 4.6 | 651.5 | - | 7.8 | - |
| SE± | 0.17 | 27.9 | - | 0.8 | - |
| CD @ 5 % | 0.50 | 78.4 | - | 2.3 | - |

Source**:** Gawankar *et al.* 2010

success both in case of seedling raised and grafted in polythene bags (67.8 %) and in earthen pots (68 %) (Dengale 1980). The grafts made on seedling raised in polythene bags attained greater vigour than grafts made on seedling raised in earthen pots (Nagwekar *et al.* 1984). The two rootstocks used for grafting a single scion resulted in superior success (68.67 % to 84.40 %) as compared to the usual method of using single rootstock (39.86 % to 61.70 %) (Dengale 1980, Gunjate *et al.* 1982). Rootstock treated with Indol Butaric Acid had superior sprouting (66.67-89.39 %), number of primary roots and dry weight than those treated with Indol Acetic Acid (Kotecha 1982).

The black coloured polybag of 15" × 20" had the highest survival (68.66 %), shoot length below graft joint (5.87 cm), number of scion shoots (1.4), highest plant height (38.17 cm), shoot length above the graft joint (28.81 cm), girth at collar region (2.92 cm) and dry weight (10.67 g) of grafts, the highest root length (70.93 cm), highest number of primary roots (39.33) and highest number of secondary roots (196.67) (Dabhole 2012).

The larger size bags (10" × 14") improved the vigour of grafts remarkably by producing longer tap root, greater root spread and more number of secondary roots with increased plant height, girth at collar, number of leaves per graft and plant spread along with superior relative growth rate over the small sized bags (6" × 8") (Haldankar *et al.* 2014).

The application of starter solution containing Urea: Single Super Phosphate : Muriate of Potash (1:2:1) had better response for increasing the height of the main stem, more number of leaves, maximum inter-nodal length of mango stone grafts throughout the growth period. Similarly $GA_4$ 400 ppm induced the maximum

**Table 4.** Effect of potting mixture on and growth of stone grafts. Hundred grafts of each treatment were prepared.

| Treatment | Success % | Sprout growth | |
|---|---|---|---|
| | | Lengths (cm) | Diameter (cm) |
| Pure soil | 82.0 | 16.5 | 5.37 |
| Soil +FYM (3:1) | 86.0 | 18.9 | 5.67 |
| Soil +FYM (1:1) | 71.0 | 19.5 | 5.94 |
| Soil +FYM (1:3) | 75.0 | 22.2 | 5.92 |
| Pure FYM | 69.0 | 17.9 | 5.37 |
| Soil + FYM+Neem cake (2:1:1) | 59.0 | 14.1 | 5.12 |
| F test | ** | ** | ** |
| SE | 3.31 | 0.39 | 0.16 |
| CD @ 5% | 9.83 | 1.18 | 0.48 |

Source**:** Dengale 1980

inter-nodal elongation, highest number of nodes, more number of branches, highest leaf area (1027.47 $cm^2$.) in mango stone grafts (More 2002). Three foliar applications of 50 % cattle urine (@ 20 ml per graft along with drenching of 50 % cattle urine @ 100 ml in polythene bag at 30 days interval to two month old stone graft helped to improve vigour of the mango plant. The drenching of humic acid at the concentration of 6 and 7 ml $L^{-1}$ for 4 and 5 times during the period of 5-12 months age showed better growth of the mango nursery grafts (*Cv*. Alphonso) (Korake *et al.* 2012).

Being a skill oriented technology it was experienced that success obtained by different grafters ranged from 81.25 to 92.00 % to obtain sufficient number of scion

material of desired variety light pruning of old mother trees is essential (Pulekar 1984, Kotecha 1982). The period from September to January was suitable for light pruning of mango mother tree (Pulekar 1984). The age of rootstocks has significant effect on success in epicotyl grafting in cashew. The maximum success was obtained with 10 days old rootstock (54 %). Success was greater with defoliated scions (59.42 %) compared with un-defoliated scions (56.85 %). The maximum success (63 %) was obtained by keeping the grafts in glass house, followed by open sun (54 %), partial shade (33 %) and complete shade (16 %). Different pruning levels of mother trees significantly affected the vigour of shoots and the number of graftable bud sticks. The maximum vigour and number of bud sticks (32.25) was obtained from lightly pruned trees followed by pinching of trees (25.75) and medium pruned trees (18.0) (Vishwasrao 1984). In jackfruit, success in epicotyl grafting was reported from April (90 %) to Mid-June (50 %) (Gunjate *et al.* 1980). The highest sprouting (74.99 %), survival (69.83 %), mean number of leaves (5.75) and mean length of sprout (6.15 cm) were observed in six months old scion sticks. The highest percentage of sprouting (69.99 %), survival (63.33 %) and superior mean lengths of sprout (5.97 cm) were recorded in the scion sticks of 10 cm length cut from terminal shoot (Desai and Desai 1989). Highest sprout length was recorded in the month of May while highest number of leaves and leaf area was observed in the month of June (Gunjate *et al.* 1980).

***Softwood grafting*:** It is now commercial method used for multiplication of horticultural plants of tropical origin (Choudhari 1984, Panicker 1986, Sawke *et al.* 1986, Shingare *et al.* 2003, Sagvekar *et al.* 2005).

In mango, soft wood grafting is possible throughout the year except heavy rains under coastal agro climatic

**Table 5.** Effect of potting mixture on sprouting, survival and growth of stone grafts. No. of grafts prepared treatment was 200.

| Treatment | Growth of grafts | | | | | |
|---|---|---|---|---|---|---|
| | No. of grafts Sprouted | Sprouting % | No. of grafts Survived | Survival % | Height cm | Diameter cm |
| Soil | 127 (52.58) | 63.50 | 115 (49.33) | 57.50 | 32.69 | 7.10 |
| Soil + FYM | 162 (64.19) | 81.00 | 152 (60.68) | 76.00 | 34.08 | 7.12 |
| Soil+Sawdust | 139 (56.51) | 69.50 | 103 (45.86) | 51.50 | 27.86 | 6.77 |
| Soil+Ricehusk | 102 (51.59) | 51.00 | 91 (42.38) | 45.50 | 32.04 | 6.89 |
| Soil+Sand (3:1) | 124 (52.88) | 63.50 | 104 (46.15) | 52.00 | 20.75 | 5.75 |
| Soil+Sand (1:1) | 114 (49.04) | 57.00 | 100 (46.25) | 0.00 | 19.00 | 5.96 |
| Soil+sand +FYM (2:1:1) | 122 (51.40) | 61.00 | 109 (47.59) | 54.50 | 27.26 | 6.56 |
| 'F' test | ** | | ** | | ** | ** |
| SE ± | 1.84 | | 1.52 | | 1.88 | 1.18 |
| CD @ 5 % | 5.41 | | 4.47 | | 5.54 | 3.53 |

(Figures in parenthesis are indicating Arcsine transformed value) **(**Source: Nagwekar *et al.*1984)

**Table 6.** Effect of poly bag size on various growth parameters of mango graft of cv. Alphonso and Kesar.

| Treatment | Length of tap root (cm) | Root spread (cm) | No of secondary roots | Plant height (cm) | Girth at collar (cm) | No. of leaves | Plant spread (cm) |
|---|---|---|---|---|---|---|---|
| 10" x 14" bag – Alphonso graft | 54.00 | 51.40 | 67.40 | 51.15 | 5.91 | 37.21 | 34.35 |
| 10" x 14" bag – Kesar graft | 46.00 | 48.40 | 75.00 | 48.10 | 5.69 | 41.39 | 43.03 |
| 6" x 8" bag – Alphonso graft | 25.00 | 3.80 | 29.20 | 32.30 | 4.90 | 26.67 | 31.68 |
| 6" x 8" bag – Kesar graft | 33.60 | 28.60 | 25.20 | 39.00 | 4.50 | 22.47 | 34.85 |
| SE ± | 5.45 | 5.04 | 3.13 | 1.88 | 0.11 | 1.18 | 1.91 |
| CD @ 5 % | 16.33 | 15.12 | 9.38 | 5.64 | 0.34 | 3.55 | 5.71 |

Source: Haldankar *et al.* 2014

**Table 7.** Effect of various treatments on survival of jackfruit stone grafts

| Treatments: Age of scion stick (months) | Survival after three month (%) | Treatments: Days of prior defoliation | Survival after three months (%) | Treatments: Length of scion stick (cm) | Survival after three month (%) | Treatments: Age of rootstock (weeks) | Survival after three months (%) |
|---|---|---|---|---|---|---|---|
| 6 | 69.83 (56.66) | Control (No defoliation) | 63.33 (52.71) | 2.5 | 4.99 (12.79) | 1 | 69.33 (56.35) |
| 5 | 56.66 (48.79) | 3 | 64.99 (53.57) | 5.0 | 23.33 (28.86) | 2 | 62.66 (52.30) |
| 4 | 53.33 (46.89) | 6 | 58.33 (49.78) | 7.5 | 63.33 (52.71) | 3 | 46.66 (43.05) |
| 3 | 28.33 (32.14) | 9 | 54.99 (47.81) | 10.0 | 63.33 (52.71) | 4 | 38.66 (38.410 |
| 2 | 13.00 (21.13) | 12 | 48.33 (44.03) | 12.5 | 53.33 (46.89) | | |
| 1 | 3.33 (10.47) | 15 | 59.99 (50.71) | 15.0 | 41.66 (40.16) | | |
| 'F' test | Sig. | 'F' test | Sig. | 'F' test | Sig. | 'F' test | Sig. |
| SE m ± | 2.41 | SE m ± | 3.36 | SE m± | 3.62 | SE m ± | 2.25 |
| CD @ 5% | 7.27 | CD @ 5% | 9.84 | CD @ 5% | 10.91 | CD @ 5% | 6.93 |

(Figures in parenthesis are indicating Arcsine transformed value) Source**:** Desai and Desai 1989

region. It was observed that the sprouting (86 %), survival (82 %) and growth were the highest in softwood grafts prepared during the month of October, while the lowest sprouting (60 %), survival (54 %) and growth were observed in the month of June. In mango cv. Alphonso, prior defoliation (77 %) did not show any significant results while comparing with undefoliated shoots. The highest percentage of sprouting and survival (87.5 %) were observed in 15 cm long scion stick of four month age grafted on rootstock with all leaves retained (72 %) The scion sticks can be stored in polythene bags, sphagnum moss and newspaper for seven days. In mango, the maximum percentage of sprouting (90 %), survival (88 %) and growth were noticed when the grafts were kept in glass house, followed by sun, partial shade and complete shade (Panicker 1986).

Softwood grafting is the successful in cashew, throughout the year except December and January. The graft success was between 73.11 and 83.66 per cent during February to November under warm climate of coastal region of Maharashtra. The rootstock should be 45 days old. The best success (59 %) was obtained by keeping the grafts in glasshouse followed by keeping it in open sun (56 %) (Vishwasrao 1984).

In cashew softwood grafting when apical bud scion sticks was used the maximum number of sprouted grafts were obtained with maximum sprouting percentage, maximum height of graft, minimum days for leaf emergence, maximum number of leaves per graft (Shinde *et al.* 2015 ).

For softwood grafting in sapota higher success of 59 to 76 per cent was found during August to September followed by May (50 to 55 per cent) with a rapid scion growth under warm and humid climatic conditions under coastal region (Waghmare 1992). The *khirni* root stock of 12 to 15 months age and scion stick of 5 months age are best suited for softwood grafting in sapota (Waghmare 1992).

October is the best month for softwood grafting in *kokum*. Two to six months old scion sticks recorded on par results for sprouting compared to one month old scion sticks. The rootstocks attained a graftable size in *kokum* in about 22 weeks; further increase in age did not influence the percentage of success significantly. The percentage success in softwood grafting ranged between 70 and 78 per cent and the highest success (78 %) was observed with 26 week old rootstock (Haldankar *et al*. 1992).

Softwood grafting in Jackfruit was simple and rapid method and recorded success rate from 33.3 to 80.0 per cent by using scions of six months growth in April followed by May (56.0 %) under coastal conditions (Gunjate *et al.* 1980).

**Table 8.** Effect of various treatments on survival of kokum softwood grafts.

| Treatments (Age of scion stick in month) | Survival after three months (%) | Treatments (days of prior defoliation) | Survival after three months (%) | Treatments (No. of leaves retained on rootstock) | Survival after three months (%) | Treatments: Age of rootstock (weeks) | Survival after three months (%) |
|---|---|---|---|---|---|---|---|
| 6 month | 84.00 (66.42) | Control (No defoliation) | 84.00 (66.42) | Control (NO) | 75.83(60.53) | 22 | 72.00 (58.05) |
| 5 month | 86.00 (68.03) | 5 days | 78.00 (62.03) | 2 | 81.67 (64.67) | 23 | 75.00 (60.00) |
| 4 month | 82.00 (64.90) | 7 days | 78.00 (62.03) | 4 | 83.33 (65.88) | 24 | 72.00 (58.05) |
| 3 month | 85.00 (67.21) | 9 days | 77.00 (61.34) | 6 | 72.50 (58.37) | 25 | 73.00 (58.69) |
| 2 month | 83.00 (65.65) | 13 days | 75.50 (60.40) | | | 26 | 78.00 (62.03) |
| 1 month | 45.00 (42.71) | 15 days | 78.00 (62.03) | | | | |
| 'F' test | Sig. | 'F' test | N.S. | 'F' test | N. S. | 'F' test | N. S. |
| SE m ± | 2.25 | SE m ± | 2.356 | SE m ± | 2.32 | SE m± | 1.62 |
| CD @ 5% | 6.76 | CD @ 5% | - | CD @ 5% | - | CD @ 5% | - |

(Figures in parenthesis are indicating Arcsine transformed value) Source: Haldankar *et al.* 1992

**Table 9.** Effect of various treatments on survival of jackfruit softwood grafts.

| Treatments: Age of scion stick (months) | Survival after three month (%) | Treatments: Days of prior defoliation | Survival after three months (%) | Treatments: Length of scion stick (cm) | Survival after three month (%) | Treatments: Age of rootstock (months) | Survival after three months (%) |
|---|---|---|---|---|---|---|---|
| 6 | 68.33 (55.73) | Control (No defoliation) | 46.66 | 2.5 | 6.66 (14.89) | 7 | 0.00 (0.00) |
| 5 | 53.32 (46.89) | 3 | 48.33 | 5.0 | 19.99 (26.49) | 8 | 0.00 (0.00) |
| 4 | 54.99 (47.81) | 6 | 41.66 | 7.5 | 58.33 (49.78) | 9 | 17.77 (24.88) |
| 3 | 26.66 (31.05) | 9 | 34.99 | 10.0 | 58.33 (49.78) | 10 | 33.33 (35.24) |
| 2 | 14.99 (22.71) | 12 | 38.33 | 12.5 | 48.32 (44.03) | 11 | 46.66 (43.05) |
| 1 | 1.66 (7.27) | 15 | 43.33 | 15.0 | 36.66 (37.23) | 12 | 53.33 (46.89) |
| 'F' test | Sig. | 'F' test | N.S. | 'F' test | Sig | 'F' test | Sig. |
| S. Em.± | 2.96 | S. Em.± | 3.39 | S. Em.± | 2.02 | S. Em.± | 1.51 |
| C. D. @ 5% | 8.93 | C. D. @ 5% | 10.21 | C. D. @ 5% | 1.55 | C. D. @ 5% | 4.53 |

(Figures in parenthesis are indicating Arcsine transformed value) Source: Desai and Desai 1989.

Jamun soft wood grafts prepared in the month of October produced maximum length of sprout (2.78 cm), maximum number of leaves (4.33). The minimum number of days (21.86) required for sprouting in the month of October (Hande 1987).

The sprouting of softwood grafts of karonda was completed in the third and fourth week from graft preparation. The grafts covered with polythene bags

**Table 10.** Effect of maturity of scion and polythene bag cover on various growth parameters of softwood grafts in *karonda*

| Treatment | Sprouting per cent | | | No. of leaves | | | No. of shoots | | |
|---|---|---|---|---|---|---|---|---|---|
| | With Polybag | Without Polybag | Mean | With Polybag | Without Polybag | Mean | With Polybag | Without Polybag | Mean |
| Hardwood Scion (6 months) | 62.50 | 22.50 | 42.50 | 8.29 | 10.03 | 9.16 | 0.39 | 0.42 | 0.41 |
| Semi hard wood Scion 4 months) | 66.67 | 30.00 | 58.33 | 11.83 | 8.73 | 10.28 | 0.37 | 0.34 | 0.35 |
| Softwood scion (2 months) | 91.67 | 60.83 | 76.25 | 14.27 | 10.93 | 12.60 | 0.42 | 0.38 | 0.40 |
| Mean | 73.61 | 37.78 | 59.03 | 11.46 | 9.90 | 10.68 | 0.39 | 0.38 | 0.39 |
| CD @ 5% | 13.46 | 10.99 | 19.04 | 1.46 | 1.19 | 2.06 | 0.05 | N. S. | 0.07 |

Source: Nimbalkar *et al.* 2011

showed more sprouting (73.61 %) than the grafts without polythene bag cover (37.78 %). The healthy, vigorous and disease free Karonda seedlings of age 6 to 9 months with 10 to 15 cm height were selected as a rootstock. Two month old scion stick (76.25 %) gave the highest sprouting as compared to four (48.33 %) and six (42.50 %) month old scion stick (Nimbalkar *et al.* 2011).

**Impact of standardised clonal propagation technology on coastal region**

Prior to development of advanced propagation technology only 10,000 grafts of mango could be prepared annually in the entire Konkan region with involvement of only few nurseries. After development and standardisation propagation technology more than 1000 of small and big nurseries in the coastal region of Maharashtra are engaged in commercial production of quality planting material of fruit crops of more than 100 lakhs grafts annually which has helped to establish area under fruit orchards rapidly for the last two decades in the coastal region of Maharashtra, Goa and Karnataka.

**Conclusions**

Availability of quality planting material on mass scale for coastal region under climatic fluctuations was one of the most limiting factors for expansion of area under horticultural plantation in the coastal region of Maharashtra. The exhaustive research has resulted in the development of clonal multiplication techniques in various fruit crops. Epicotyls grafting and softwood grafting in mango, softwood grafting in cashew, jackfruit, jamun, karonda, kokum, nutmeg, sapota and air layering in cinnamon have contributed for rapid multiplication of these crops resulted in quantum increase in area expansion in coastal region of Maharashtra.

**Acknowledgment**

The authors are thankful to Department of Horticulture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Dist-Ratnagiri (M.S.) for their help in recording observations of various research experiments. The authors are also grateful to expertise provided by the Directorate of Cashew Research, Puttur, Karnataka and Indian Institute of Horticulture Research, Bengaluru, Karnataka.

**References**

Choudhari U. N. 1984. Studies on epicotyl and softwood grafting in cashewnut (*Anarcardium occidentale* Linn.). M. Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Dabhole S. V. 2012. Effect of colour and size of polybags on growth and survival of mango grafts (*Mangifera indica* L.). M.Sc. (Agri.), Thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

de Andrade O. S. 1983. Studies on propagation of kokum (*Garcinia indica* Choisy.). M.Sc. (Agri.) Thesis submitted f to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Dengale K. M. 1980. Studies on stone grafting on mango (*Mangifera indica* L.). M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Desai S. A. and Desai A. G. 1989. Effect of age, length, defoliation and storage of scion sticks on success of softwood grafting in *Artocarpus heterophyllus*, proceedings of Indian Academy Science. Plant Sci. 99: 585-591.

Divekar P. B. 2011. Studies on vegetative propagation of karonda (*Carissa carandus* L.) A M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Gawankar M. S., Salvi B. R., Chavan S. A. and Dalvi N. V. 2010. Comparative performance of mango varieties grafted on Vellaikolamban and mixed rootstock. J. Hort. Sci. 5: 114-116.

Gunjate R. T., Dhakal D. D., Limaye V. P. 1982. Stone grafting in mango under Konkan conditions. Indian J. Hort. 39: 45- 49.

Gunjate R. T. and Limaye V. P. 1978. Veneer grafting in mango

seedlings raised in earthen pots. J. Maharashtra Agri. Univ. 3: 61-62.

Gunjate R. T., Kolekar D. T. and Limaye V. P. 1980. Epicotyl grafting in Jack. Curr. Sci. 49: 667.

Gunjate R. T., Uradva V. S. and Limaye V. P. 1976. Effect of season and defoliation of scion shoots on success in veneer grafting in 'Alphonso' mango. J. Maharashtra Agri. Uni. 3: 51-52.

Haldankar P. M., Parulekar Y. R., Kulkarni M. M. and Lawande K. E. 2014. Effect of size of polybag on survival and growth of mango grafts. J. Plant Studies 3: 91-95.

Haldankar P. M., Salvi M. J., Joshi G. D. and Patil J. L. 1992. Standardization of softwood grafting in Kokam. J. Maharashtra Agri. Uni. 17: 227-229.

Hande R. B. 1987. Propagation of jamun (*Eugenia jambolana* L.). M.Sc. (Agri.). Thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Harnekar M. A. 1980. Studies on vegetative propagation of cashewnut (*Anacardium occidentale* L.) and Jackfruit (*Artocarpus heterophyllus* L.). M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Kelaskar A. J. 1988. Studies of propagation of jackfruit (*Artocarpus heterophyllus* Lam.) by different methods of budding under Konkan conditions. M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, 1988.

Kolekar D. T. 1979. Studies on propagation of jackfruit (*Artocarpus heterophyllus* LAN.). M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Korake G. N., Haldavnekar P. C., Haldankar P. M., Mali P. C. and Burondkar M. M. 2012. Effect of Humic Acid on physiological growth of mango (*Mangifera indica* L.) nursery grafts var. Alphonso under costal eco system. J. Indian Soc. Coastal Agric. Res. 30: 19-23.

Kotecha S. M. 1982. Studies on improving survival of mango (*Mangifera indica* L.) stone grafts. M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Lynch S. J. 1941. Nursery propagation and top-working of mangoes. Fla. Agric. Exp. station press Bull. 560.

Majumder P. K. and Mukherjee S. K. 1961. A note on the propagation of rootstocks in mango. Indian J. Hort. 18: 167-168.

More M. M. 2002. Effect of starters and growth regulators on sprouting, survival and the growth of mango (*Mangifera indica* L.) stone grafts. Thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Nagwekar D. D., Gunjate R. T. and Salvi M. J. 1984. Effect of various factors on survival of mango stone grafts. J. Maharashtra Agri. Uni. 9: 281-284.

Nimbalkar S. D., Haldankar P. M., Pujari K. H., Dhekale J. H. and Somavanshi A. V. 2011. Effect of maturity of scion and polythene bag cover on softwood grafting of karonda (*Carissa carandus* L.) Indian J. Hort. 68: 429-432.

Panicker P. 1986. Studies on softwood grafting in mango var. Alphonso. M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Patil R. D., Gunjate R. T. and Salvi M. J. 1986. Effect of storage conditions on viability of mango stones. J. Maharashtra Agric. Univ. 11: 362.

Prasanta Kumar Maity. 2007. Studies on different planting systems, rootstock trial and performance of some mango hybrids under new alluvial zone of west Bengal. Thesis submitted to Bidhan Chandra Krishi Viswavidyalay, West Bengal.

Pulekar S. C. 1984. Studies on effect of pruning and application of fertilizers on production of bud stick in Alphonso mango and utilization of bud sticks. M.Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Sagvekar V. V., Patil B. P., Shingre D. V., Gawankar M. S. and Chavan A. P. 2005. Success of Cashew grafts cv. Vengurla-4 as influenced by polished environments. J. Agromet. 7: 262-267.

Sawke D. P., Salvi M. J. and Patil M. M. 1986. Softwood grafting – A sure technique of clonal propagation in cashew. Indian Cashew J. 17: 17-18.

Shinde V. V., Mahale M. M., Jadhav P. V. and Dubale J. J. 2015. The effect of type of scion stick on success of softwood grafting in cashew Anacardium occidentale var. 'Vengurla 4' International Symposium on Cashewnut ISHS. Tamilnadu, India.

Shingare D. V., Gawankar M. S., Jamdagni B. M. and Joshi G. D. 2003. Standardization of the month of grafting and age of rootstock in cashew. The Cashew. pp.35-39.

Vishwasrao V. V. 1984. Studies on some aspects of propagation of cashewnut (*Anacardium occidentale* L.). M. Sc. (Agri.) thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Waghmare G. M. 1990. Studies on standardization of softwood grafting in Sapota (*Manilkara achras* Mill.) var. Kalipatti. M.Sc. (Agri.) Thesis submitted to Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.