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REJUVENATION OF MANGO FOR SUSTAINABLE FRUIT PRODUCTION: A REVIEW

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ABSTRACT

India has witnessed incredible growth in the production of fruit crops in recent years due to specific interventions in crop improvement, production and postharvest aspects. India ranks second in fruit production in the world, after China. However, the productivity per unit area is very low compared to the other mango growing countries. The old, unproductive and seedling origin mango orchards are now reverting to a low production trend of mango fruit production because of plant age and poor canopy management. The present review paper aims at importance of rejuvenating the old and unproductive orchards for sustaining their production capacity without fresh plantation. The rejuvenation technology may help old, seedling origin and senile orchards for sustainable fruit production with higher growth and fruit quality characteristics *viz.*, fruit-weight, fruit colour, TSS, acidity and shelf-life etc.

Key words : Mango, Rejuvenation, Pruning, Canopy, Fruit, Yield and Quality.

Introduction

Mango (*Mangifera indica* L.) is considered as one of the oldest cultivated fruit crops of India and belongs to the family Anacardiaceae. It is indigenous to North East India and North Burma, in the foot hill of the Himalayas and is said to have originated in the Indo- Burma region (De Candolle, 1904). Mango has been cultivated for thousands of years in India (Mukherjee, 1953) and its cultivation is as old as Indian civilisation. Mango is one of the most relished fruits in India and remains unique, delicious crop; it is the part of Indian culture and religion since ancient time and thus, becomes 'National fruit'. Because of its sweet peerless test and richness in phytochemical and nutrient content, it is called as the King of Fruit. Mango having good nutritional value as every 100 g of mango fruit contains 81.7 g water, 16 g carbohydrate, 0.7 g protein, 0.4g fat and 0.1 g fibres. It is rich in calcium, phosphorus, iron, magnesium, Vitamin-A, B, C and also anti-oxidants.

A single fruit can provide up to 40 percent daily dietary fibre needs. Mango fruits having various uses from unripe to ripen stages, unripe mangoes are used for making pickles, marmalade, amchur, tannin, soft drinks etc. while fully ripe mangoes are used for pulp making, jam, squash, candy and papads etc. The mango trees are growing well under a wide range of agro climatic situation in the country and can grow well in all type of soil from alluvial to lateritic, except highly calcareous soils. It does well within temperature ranging from 24-30^{0}C, although it can successfully endure even temperature as high as 48^{0}C during the period of fruit development and maturity. Cold temperature limits for crop production. Mango can grow from sea level to an altitude of about 1400 meters provided that there is no very high humidity, rain, cold waves or

frost particularly during the flowering period (Ram *et al*., 2005; Reddy and Kurian, 2011).

The current leading mango producing nations after India include China, Thailand, Pakistan, Mexico, Indonesia, Brazil and Philippines. The fruit is highly valued because of its excellent flavour, appealing aroma, delicious taste, attractive shades of colour and nutritive value, which has attracted the world market. At present in India, mango is cultivated in an estimated area of 2.29million hectare with 20.44 million tons of fruit production and productivity. Important mango producing Indian states are Uttar Pradesh, Andra Pradesh, Karnataka, Telangana, Bihar and Gujarat. In West Bengal, total area under mango cultivation is 1 about 9074 thousand ha and production is about 836.07 metric tons with 8.54 t ha^{-1} productivity (Anonymous, 2020).

Mango was commonly propagated by seeds in earlier times and the propagation practices have been replaced by different ways of grafting. It is a highly heterozygous crop and seedling nature of trees could bear fruits over 60 years and often produces inferior fruit quality. The seedling trees shows declining the productivity after 40 years of age, whereas, the grafted mango nearly becomes less productive after 25-30 years of planting. The other reasons of low productivity include large number of unwanted and unproductive branches, insect-pest attack, old and poor-yielding variety, unmanageable size of tree, rainfed cultivation and improper irrigation and nutrition management. Low yielding mango plantations are considered as a liability than an asset to the grower. Adoption of improved cultural practices like regular manuring, irrigation and timely plant protection measures etc. increase the yield to a certain extent, but raising the level of productivity of existing low yielding orchards in short span of time is only possible if, these plantations are rejuvenated. High density planting of mango (5×5m or even low) is gaining popularity day by day for more productivity. But improper canopy management along with none or less practicing of good horticultural management leads to overcrowding of trees resulting unproductive and uneconomic orchards. Several efforts were initiated to standardize the technology for restoring the production potential of existing plantations by exploring the management technique known as rejuvenation (Sree Hari and Subi Reddy, 1998; Baba *et al*., 2011; Parulekar *et al*., 2019).

Need for rejuvenation

The productivity of mango per unit area in India is very low compared to the other mango growing countries. It may be due to the old and unproductive orchards of seedling origin and improper pruning techniques followed in bearing mango orchards. To overcome this problem of low yield and quality of mango though rejuvenation is more effective gardening technique to recover yield potential of the old and unproductive orchards. This technique has potential to reduce production gap in very short time compared to production from fresh plantations. Rejuvenation is promising technique to revitalize old and senile type sand transform them into productive, with the advantage that rejuvenated trees commence commercial bearing earlier as the old trees are well established in the soil condition and developed resistance could be made by effective use of this technique (Singh *et al*., 2017; Pathak *et al*., 1996; Paramjeet *et al*., 2020).

The old and unproductive mango orchards need to be rejuvenated as they demonstration in poor yields and low fruit quality, which may be attributed to any one of the following reasons:

- Reduction in the photosynthetic surface area.
- Non availability of productive shoots.
- Increased incidence of insect pests and diseases.
- Less penetration of sunlight due to overcrowding of branches as a result of which the fruits on the interior areas of the tree do not develop proper colour.

Rejuvenation is the process of pruning and after pruning management of the plants to make them productive by utilizing the existing root system, restoring the productive capacity of the fruit trees. The rejuvenation makes the plant manageable, easy for adoption of appropriate package of practices, improving vigour and yield. Ontogenetic rejuvenation can be thought of as a resetting of the aging clock back to the juvenile stage, whereas physiological rejuvenation involves slowing down the aging clock. Under stressful conditions, it is common to find individuals of a given species living much longer than they typically would under more favourable conditions. Rejuvenation of mature parts facilitates the availability of juvenile parts (Burondkar *et al*., 2013; Uddin *et al*., 2014). Thus, rejuvenation in mango is adoption of suitable pruning, adequate nutrient and plant protection management, development of appropriate canopy and other management operations in a holistic manner (Lal and Mishra, 2008; Burondkar *et al*., 2018; Jotava, 2020).

Result of rejuvenation on growth attributes of mango

Rejuvenation of old and unproductive mango orchard have important role to rebuild canopies and productivity of trees. Decline in productivity of senile mango orchards

Fig. 1 : Over all view of rejuvenated old mango orchard.

Fig. 2 : Fertilizers application in rejuvenated orchard.

Fig. 3 : Shoot growth on rejuvenated mango plant.

is largely due to dense, intermingling, overcrowding and pest infested branches with more of wood mass and canopy of unhealthy shoots. It certainly saves the infrastructure establishment and will come to bearing at early stages as compared to new plantations.

Severe pruning i.e. beheading is needed to alter not only physiology but also biochemical behaviour of these senile old mango trees. It is necessary to standardize the beheading height of old mango trees so that shading does not occur in skirts of tree canopy and on adjacent rows (Sharma and Singh, 2006) and also to re-establish the canopy at low and within easy reach for management. Shorter trees have more accessible canopies and are easier to harvest, prune and spray, require fewer labour inputs. Fruit crops are managed to facilitate light penetration into the canopy, the photosynthetic activity during fruit growth period might be augmented to increase yield (Durand, 1997; Gross, 1997; Vinod *et al*., 2017; Rana and Reddy, 2018; Usha Rani, 2018; Meena *et al*., 2022).

Rejuvenation is the process of pruning and afterwards management of the plants. In this technique the dormant buds on stem are activated which takes about 40-60 days for visible sprouting (Dabhole *et al*., 2018). Rejuvenation technology involves heading-back of 3-4 branches at a height of 2.5-3.0 m from ground and thinning of remaining branches during December (Anonymous, 2009). Gibberelic acid can protect the native or exogenous axuin from inactivation in tissues by increasing native auxin synthesis, or it can increase the number of sites available with auxin molecules that can react to promote growth. Pruning adjusted the total partitioning of dry weight in such a way that more dry weight added to new shoots than the remaining wood of the frame, trunk and roots (Mika, 1986; Singh *et al*., 2019).

Schaffer and Gaye (1989) measured the total leaf chlorophyll concentration in several positions during April, July and November in canopies of pruned and non-pruned mango cv. Tommy Atkins. The total leaf chlorophyll content was highest during November for pruned trees, but identical during April for pruned trees. Burondkar *et al*. (2000) recommended hard pruning of mango cv. Alphonso during the first fortnight of March and soil application of paclobutrazol @ 5-7 g per tree in July or August of following year during rejuvenation for optimization of yield of 40-year-old mango orchard cv. Alphonso. Davenport *et al*. (2007) examined the relationship between endogenous gibberellic acid and mango shoot development. They reported that rapid shoot growth is connected to GA synthesis. It is thought that GA3 enhance or sustain endogenous auxin synthesis or activity, as a result, it retains a high auxin/cytokinin ratio.

Lal *et al*. (2000) rejuvenated 45year old mango trees of cv. Dashehari (planted at 8×8m) distant with different pruning levels. After six years of pruning, the maximum length (2.1m) and girth (22.21cm) of emerged shoots was recorded in first order pruning (branches emerged from main trunk), while, the minimum was in control (0.62m and 10.79cm, respectively). However, maximum cumulative fruit yield of 330.92 kg/tree was registered in fourth order pruned trees (shoots emerged from tertiary braches) than control (131.81 kg/tree).

Banik and Sen (2002) conducted an experiment on rejuvenation of unproductive, 30 to 50 years old mango cv. Fazli by giving five pruning treatments in July with

two levels of fertilizers. Highest number of shoots (23.50) was recorded in leader intact, removal of 1st order branches surrounding the leader with N, P and K at 1.5, 0.75 and 1.5 kg /plant, respectively in combination of 3 percent urea spray in 30 to 40-year-old tree. The highest increase in girth of the trunk (4.55 cm) was recorded in heading back of leader branch with N, P and K at 1.5, 0.75 and 1.5 kg /plant, respectively in combination of three percent urea spray in 30 to 40-year-old tree than tree of 40 to 50 years and above treatment combination.

Result of rejuvenation on yield attributes of mango

In old and dense mango orchards, light interception and photosynthesis potential of orchard trees is reduced. In such orchards, selective pruning and thinning of crowded branches for proper air circulation, improved photosynthetic efficiency, fruit yield and quality has been reported in many fruit crops by earlier researchers (Das and Jana, 2013). Lal and Mishra (2008) studied the impact of various pruning levels on the 45-year-old, dense and declined mango cv. Dashehari. First-order pruned trees gave maximum increases in tree height and shoot girth, while fourth-order pruned trees recorded the highest shoot length and the distribution of canopy was highest in control. Severely pruned trees showed loss in fruit yield for the initial two years, which subsequently increased, but moderate and light pruned trees produced fruits up to 3 to 4 years from the first year in increasing pattern.

Bamini *et al*. (2009) investigated the rejuvenation of a forty years old senile mango cv. Neelum by combining different pruning intensities, such as "severe pruning" and light pruning with soil application of paclobutrazol to induce good yield and fruit quality. The results showed that the treatment of severe pruning with paclobutrazol resulted in larger fruits, while the treatment of light pruning with paclobutrazol resulted in a higher number of fruits harvested per tree. Hasan *et al*. (2009) conducted rejuvenation of unproductive, dense and overcrowded 40 years old mango orchards of Himsagar variety spaced at 8x8 m in December. Maximum shoot length was recorded during August (22.90cm) and March (30.11cm) pruning of all branches at 4.0m height. While, a greater number of leaves were recorded in 5.0m height pruning during the months of August (25.0), September (20.0) and October (16.0).

Singh *et al*. (2010) studied endogenous phytohormones changes after pruning in three mango cultivars, *viz*. Amrapali (2.5m×2.5 m), Mallika (4.0m×3.0m) and Dashehari (3.0 m×2.0 m). Light pruning (30 cm from the apex), moderate (60 cm from the apex) and severe (90 cm from the apex) pruning was done in mid-August, with unpruned as control. Significant effect was observed in level of endogenous hormones in shoot buds by pruning in both biennial and regular bearing mango cultivars. The maximum IAA, ABA and minimum GAs were found in 'on' year of mango shoots and they concluded that the shoot-tip pruning stimulate the axillary bud development by removal of the source of apical dominance. Highest IAA levels recorded in moderately pruned treatments, whereas, control trees had the lowest IAA and the highest GA-like substances.

Twenty-four-year-old mango cv. Amrapali (planted at 5 × 5 m distance) were yields of more than 60 kg/tree were reported for 1.5 m and 2.0 m pruning at 1.0 m and 60 cm length of primary shoot (Das and Jana, 2013). Raj *et al.* (2017) studied on old senile mango cv. Amrapali pruned at 1.5 m height from ground level and they recorded those maximum total phenols content (53.09 mg g^{-1}) was estimated in plants of paired planting system whereas, minimum total phenols content was recorded in hedgerow planting system (41.08 mg g^{-1}). Thirty-year-old, high density planted (5m×5m) mango orchards of two varieties (Kesar and Vanraj) with three rejuvenation levels (1.0m, 1.5m and 2.0m) were investigated (Kshirsagar *et al*., 2017). The highest number of sprouts was recorded at a height of 2.0 m on the primary and secondary branches of rejuvenated trees. The rejuvenation at the height of 2.0m expressed bud sprouting in Kesar at 20.53 days and Vanraj required 29.54 days. Whereas, rejuvenation at 1.0m resulted sprouting at 31.67days and 46.53days, respectively. Pruning increased the mean cumulative fruit yield for four years, which was almost double that of control, although the two pruning treatments were on par. Maximum mean cumulative fruit yield (86.3kg/plant) was obtained with 30cm pruning, whereas control treatment recorded a fruit yield of 47.2kg/plant.

Result of rejuvenation on quality attributes of mango

Fruit quality attributes such as average fruit-weight, TSS, acidity and shelf-life were not affected by the two pruning treatments, for rejuvenation of 'Alphonso' mango (Reddy and Kurian, 2011). Kitt mangos greatly affected with both pruning pattern and soil mulching, there were an evident increase in fruit set %, total yield (kg/tree) and marketable yield % with one-third and one-half pruning of branch and also with white and black plastic of soil mulching. Fruit chemical constituents including TSS%, acidity and L-ascorbic acid slightly affected with different treatments but one-third and one-half pruning of branch as well as with white and black plastic of soil

mulching (Salama *et al.*, 2018).

The higher total soluble solids (22 ºBrix), total sugars (15.40%), reducing sugar (5.35%) and minimum titratable acidity (0.15%) were observed in cv. Langra when plants are rejuvenated compare to non-rejuvenated plants. This effect might be due to the increased rate of photosynthesis led by more light penetration into the interior tree canopy which in turn led to increase in quality of mango fruit. Similar results on fruit quality properties were reported by Anonymous (2011), Reddy and Kurian (2011) and Singh *et al*. (2010), Patel *et al*. (2013) in mango and Venkataramudu *et al*. (2018) in pomegranate.

Conclusion

Rejuvenation of old and unproductive orchards are scientifically proven that they are highly potential enough to improve the fruit productivity. Our ultimate aim in higher fruit production is to increase the production by increasing the productivity with the effective utilization of crop canopy. Since the orchard establishment and development is a long-term process and cannot be done in one year. but once the yield is reduced to such an extent that orcharding becomes non-economical, rejuvenation is said to be essential as it:

- Rejuvenation helps in restoring the production potential of old orchards in shortest possible period.
- Rejuvenation helps in in maintaining the tree height with open architecture.
- It enhances the fruit production and quality without affecting his economy to a great extent.
- To remodify low yielding and inferior quality old trees into better and high yielding types.
- Improved inter row light interception.
- Promote plants survival under limiting soil and climatic condition.
- Reduce/restrict damage to plant parts and high disease(s) impact.
- Enhance tree Vigor and economic age of old tree.
- Finally enhance orchard income with reduced costs.

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