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Special Section

Mango: An Economic Pillar of Konkan Region of Maharashtra

M. M. Burondkar*[1], M. M. Kulkarni[1], B. R. Salvi[1], K. D. Patil[1], A. L. Narangalkar[1], M. S. Joshi[1], J. M. Talathi[1], V. G. Naik[1], D. B. Malave[1], S. S. Bhosale[1], A. C. Deorukhakar[1], S. R. Bagade[1], V. K. Patil[2], A. D. Rane[2], S. B. Dodake[3], P. M. Haldankar[4] and T. Bhattacharyya[4]

[1]College of Agriculture (DBSKKV), Dapoli, Maharashtra (India) 415712
[2]College of Forestry (DBSKKV), Dapoli, Maharashtra (India) 415712
[3]Kharland Research Station (DBSKKV), Panvel, Raigad, Maharashtra (India) 410206
[4]Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra (India) 415712

ABSTRACT

Konkan region on the west coast of India traditionally known for the commercial cultivation of world famous Indian mango variety "Alphonso", presently occupying more than 1.8 lakh ha of land area, accounting for nearly 6 percent of the total mango area in the country. Poor mango orchard efficiency (2.5- 3.0 t ha^{-1}) and high annual fluctuations in mango crop, due to "on" and "off" year of bearing habit, are considered as long standing constraints in sustainable mango farming in Konkan. Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, since its establishment in 1972, has been carrying out all round, multidisciplinary research on various aspects of mango, to overcome these constraints. Over the past 45 years, university has developed and recommended more than 150 individual technologies for the yield and quality improvement in mango, From bunch of several recommended technologies, five key integrated technologies, which are most crucial ,high impact generating, and cost effective, were identified and clubbed into five points and scheduled to fit into annual mango growth cycle in Konkan. These include: First, tree-specific, need-based, timely followed integrated nutrient management at the onset of monsoon i.e. June. Second, for ensuring regular and early flowering, tree-specific optimum dose of Paclobutrazol, applied at right time by adopting right method during July-Aug. Third, scrupulously following university recommended plant protection spray schedule, starting from post-monsoon pre-flowering till setting of marble stage fruits i.e Nov. to Mid Feb. Fourth, need-based sprays for foliar feeding of nutrients and growth regulators and 5-6 irrigations at weekly interval, starting from peanut stage, to ensure good fruit set and quality of fruit (Feb. to March). And fifth, post-harvest canopy management, adopting recommended tree specific pruning techniques for harnessing maximum sunlight for assimilation of maximum food through photosynthesis during May. Field demonstration of these five integrated key technologies have established that this approach holds potential in doubling DFI under aberrant climatic conditions in Konkan. Experiment was undertaken on 16-years old 400 mango trees in the orchard in Dapoli for consecutive 3 seasons (2014, 2015 and 2016). As compared to normal block, almost every tree in the orchard, which received above five inputs, spectacularly exhibited profuse flowering, heavy fruit setting and abundant fruiting (500 to 650 fruits per tree), consecutive for three years, inspite of aberrant climate of Konkan region during last few years. Details of the five points integrated technology and its demonstrations along with very impressive benefit:cost ratio are presented in this chapter.

***Corresponding author**: burondkarmm@yahoo.co.in
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Introduction

Mango is rightly known as 'King of fruits' owing to its nutritional richness, unique taste, pleasant aroma and its religious, medicinal importance and tasted by all corners of world. It is considered as 'National fruit of India' and is believed to be originated in South East Asia, Indo Burma region, in the foot hills of the Himalayas (Mukherjee 1951). It has been variously called *Amra, Chuta, Rasala, Sahakara, Atisourabha* in ancient Sanskrit literature and the tree has been described as Kalpa-Vriksha or the wish-granting. It has

an intimate association with cultural, religious, aesthetic and economical life of Indians since time immemorial (Chattopadhyay and Nandi 1976).

Mango (*Mangifera indica* L.) is one of the 73 genera of the family Anacardiaceae in order Sapindales. It is the most important tropical fruit of the world. It can also be grown in the subtropical conditions and up to elevations of 1400 meters above the mean sea level. The optimum temperature range for growth is 18 to 35 °C and it can tolerate temperatures as high as 48 °C. It can survive in areas having an average annual rainfall ranging from 250 mm to 2000 mm. Loamy, alluvial, well drained, aerated and deep soils rich in organic matter with a pH range of 5.5 to 7.5 are ideal for mango cultivation.

The total world production of Mango is 43.3 lakh tonnes (Anon. 2015a). It is commercially grown in more than 111 countries but nowhere it is as greatly valued as in India where 40 % of area under fruit crops is only under mango. India is the largest producer of mango in the world, and ranks first in area and production. The total production of mango in India is 18.431 MT from about 2.516 million ha area with the productivity of 7.3 MT ha^{-1} (Anon. 2015b). India contributes about 64 % of the world mango production. According to the APEDA, in the year 2014-15 India exported 42,998 tonnes of mangoes worth Rs. 302 crores (Anon. 2015c). In Maharashtra, mango is occupying an area of 4.82 lakh ha with annual production of 6.33 MT with productivity of 1.3 MT ha^{-1} (Anon. 2015b). In Konkan, 1.10 lakh ha productive area was under mango cultivation having annual production of 2.6 lakh MT. The productivity of mango in Konkan is about 2.5 to 3.0 MT ha^{-1}, which is about three times less than the average productivity of the country (Anon. 2015d).

Alphonso is a leading variety in Konkan region in terms of area and production; which is locally called as 'Hapus'. It thrives and yields early under warm and humid climate of Konkan region. Alphonso is considered as one of the choicest variety because of its earliness, keeping quality, typical sugar-acid blend, aroma, processing potential and thus holding major share in export of fresh mangoes and mango pulp among the mango varieties from India. Inspite of this, Alphonso has some inherited drawbacks. Poor mango orchard efficiency (2.5-3.0 t ha^{-1}) and high annual fluctuations in mango crop, due to "on" and "off" year of bearing habit, are considered as long standing constraints in sustainable mango farming in Konkan. Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, since its establishment in 1972, have been carrying out all round, multidisciplinary research on various aspects of mango, to overcome these constraints. Over the past 38 years, university has developed and recommended more than 150 individual technologies for the yield and quality improvement in mango, From bunch of several recommended technologies, five key integrated technologies, which are most crucial, high impact generating and cost effective were identified and clubbed into five points and scheduled to fit into annual mango growth cycle in Konkan.

Annual growth cycle of mango in Konkan

Mango crop particularly in Konkan starts its annual growth cycle in June with onset of monsoon and ends with a rest period after harvesting of mango in May of next season. New flush up to 80 % is expected to sprout on the tree during June-July which will take a time of three month to get mature in low light intensity during rainy season and became mature up to September-October. These mature flush remain dormant for next two to three month up November to December. It actively manufactured carbohydrates up to January and then initiates the process of flowering. It takes nearly 100 to 120 days for fruit development. The annual cycle ends with harvesting of mango fruits in the month of April to May followed by rest up to onset of Monsoon. So to get fruits on time tree must flower on time and hence for getting flowers on time it is important that tree should develop vegetative flush at correct time. Fluctuation in the any phase of the cycle directly affects the yield of crop resulting in gain or loss.

Farmers are more focusing on flowering, protection and aftercare during fruit development. But it is also equally or more essential to produce young and healthy flush on time and its management for flowering. Out of last 10 years, 4 years (2010, 2011, 2013 and 2016 received rain 25 to 35 % more than the average and one year (2015) recorded 35 % less rain than the average. Intensity of rain has also increased up to November during last five years. These climatic fluctuations will surely impact the growth cycle of mango tree and will keep the trees always in confusing stage. It was observed through research and also from farmer's field demonstrations that timely use of five point integrated technology helped for getting sustainable yield of mango with cost effectiveness. Before using the technology, it is essential to number the trees in the orchard with oil paint on trunk to classify them as per their growth and canopy

From bunch of several recommended technologies, five key integrated technologies, which are most crucial, high impact generating, and cost effective, were identified and

clubbed into five points and scheduled to fit into annual mango growth cycle in Konkan. These include: 1.Tree specific, need based, timely followed integrated nutrient management at the onset of monsoon, (June)

2. For ensuring regular and early flowering, tree specific optimum dose of Paclobutrazol, applied at right time adopting right method (July-Aug.)

3. Scrupulously following university recommended plant protection spray schedule, starting from post monsoon pre-flowering till setting of marble stage fruits (Nov. to Mid Feb.)

4. Need based sprays for foliar feeding of nutrients and growth regulators and 5-6 irrigations at weekly interval, starting from peanut stage, to ensure good fruit set and quality of fruit (Feb. to March)

5. Post-harvest canopy management, adopting recommended tree specific pruning techniques for harnessing maximum sunlight for assimilation of maximum food through photosynthesis. (May)

Point 1: Application of balanced recommended nutrition on the basis of yield of last year and vigor of the tree (May–June)

Mango trees though planted at the same time in an orchard resulted in different size of canopy and growth rate. Appropriate nutrient management is one the most important aspect in mango production technology. The inadequate supply of nutrients as well as overdoses of nutrients may be harmful for obtaining more yield as well better quality of mango.

Classification of trees in Orchard

Application of nutrient should be need base and one month prior to application of Paclobutrozol on the basis of previous year yield and canopy size. Hence after the numbering it is essential to classify trees on following classes (Table 1).

Recommended dose

For a tree age of 15 to 20 years giving fruit yield up to 300 fruits, nutrient dose recommended is 50 kg organic manure (60 % compost + 40 % fish manure) + 1.5 kg N + 0.5 kg P_2O_5 + 1.0 kg K_2O. Potassium should be applied through sulphate of potash (Shinde *et al*. 2006). On the basis of leaf analysis at every alternate year, need base spraying of Secondary (Ca, Mg, S) and micro nutrient ¼Fe, Mn, Zn, Cu, B½ (50 to 100 g) is also advocated.

Application of fertilizer on the basis of above classes will save the input, energy and money. It will also help to stop unwanted vegetative growth

Methodology

Application of manure and fertilizer dose should be done as per recommendation of Dr. B, S. Konkan Krishi Vidyapeeth, Dapoli. Application is need to be done at onset of monsoon and if irrigation available immediately after harvest. It is applied by digging a ring at equal distance from the center of trunk and edge of canopy with pick axe and spade. Ring should be 20 cm deep, 30 cm wide. (Plate 3) First bottom layer in ring should be of half decomposed leaves followed by manure, fertilizers, manure and finally it should be covered with top soil. Excess dose of fertilizer leads to vegetative flush even after rains which fail to obtain desirable flowering due to application of Paclobutrozol.

Point 2: Application of Paclobutrozol as per recommendation (July–August)

Alternate bearing is a very serious disorder in Alphonso mango cultivated in Konkan Region of India. An endogenous high level of gibberellins has proved a major hindrance in the way of flower bud differentiation in a number of tropical fruits including mango (Kachru *et al.* 1971, Tomer 1984). To overcome the inhibitory effect of gibberellins, Paclobutrolzol, a broad spectrum, gibberellins biosynthesis inhibitor is being successfully evaluated almost in all major mango growing countries over a wide range of varieties (Burondkar and Gunjate 1991)

Role of Paclobutrozol in induction of flowering

Application of Paclobutrozol through soil significantly controlled tree vigour in Alphonso mango. This was medicated by supressing the emergence of vegetative flush generally coincides with flowering and delays induction of flowering. The effect was also attained by reducing shoot elongation. In a research carried out

Table 1. Classification of Trees and application of fertilizers

Classification of tree	Dose
A: Healthy Tree but off season last year	50 % N of Recommended Dose + P & K
B: Healthy Tree and good yield last year (300 fruits tree^{-1})	Recommended Dose of NPK (Can be increased as per Yield)
C: Unhealthy Trees	Two split doses of N in June – September + P and K in June

for three cropping years, indicated that paclobutrozol application discouraged unwanted vegetative growth and induced early (3 to 4 weeks), profuse flowering (80 to 85 %) for all the three consecutive years. (Burondkar and Gunjate 1993)

Recommended dose

Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli after research of ten years (1987 to 1997) recommended that the application of paclobutrozol @ 0.75g a.i. meter^{-1} average canopy diameter (3 ml per meter canopy diameter) from 15th July to 15th August ensures regular flowering in mango. Under high density planting, where plant canopy diameter is less than 5 to 6 meter due to canopy management by pruning, multiplication factor value be 2 and not 3. However, paclobutrozol should be applied every year for regular bearing. However, application of paclobutrozol must be accompanied with appropriate recommended nutrient management and plant protection measures.

PBZ _____ ml/ 3 to 5 Lit = Average canopy diameter (NS + EW)/2 = _____ m x 3

Methodology

Paclobutrozol is applied by soil drenching. Before application of Paclobutrozol, the exact quantity is estimated by measuring the canopy diameter. Paclobutrozol can be applied in traditional orchards after 10 years of planting. A required quantity of paclobutrozol be dissolved in plastic bucket containing 3 to 5 L of water. Twenty five to Thirty small holes (10 to 15 cm deep) with the help of kudali are dug around the tree basin just inside the manuring ring, at uniform distance. Then the uniform quantity of prepared solution is drenched into holes. After application the holes should be closed or plugged. Important precautions are weeding should be done before application of paclobutrozol and the soil should be sufficiently wet at the time of paclobutrozol application.

Methodology for mango orchard developed on coast by doing blasting

Mango orchard of Alphonso varieties were developed by farmers on sea coast by doing blasting in red lateritic hardrock and filling the blast area with good quality soil. In such orchards, drainage of water is fast and trees are exposed to salty air for 3 to 4 months resulting in stress condition helpful for early flowering. In such orchards Paclobutrozol is applied to mango trees with healthy and vigorous canopy in the second fortnight of May (If irrigation facilities are available) or immediately after onset of rains in June. It was observed that fruits on these trees will be available for harvesting from end of February to March. Selection of trees is important criteria as 20 to 25 % of trees will be available in such orchards which fetch four to five times more cost in the season.

Residual effect of PBZ

Less dose of Paclobutrozol results in less amount of flowering but excess application results in to a bunch type inflorescence. It was also observed that the new flush remain dwarf and stagnated like a bunch. Such trees should be supplied with half dose of Paclobutrozol next year. This effect will get subsidized with a sprouting of new flush after flowering. Recommended dose has showed very very negligible residue (0.01 to 0.03 mg kg^{-1}) as against permissible residue level declared by FPO (0.05 mg kg^{-1}). Hence there is no banned on fruits applied with Paclobutrozol (recommended dose and method) in international market.

Point 3: Flush and blossom protection through Integrated pest and disease management (October - February)

High atmospheric humidity in Konkan region is the major reason behind high incidence of pest and disease infestation. After application of Paclobutrozol in August, it is essential to protect maturing flush form pest and diseases up to flowering. It is equally essential to protect inflorescence and fruits during development stages. There are total 12 pests and 7 diseases mainly affecting twigs, leaves, flush and inflorescence in mango.

Hence schedule developed by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli (Table 3) for integrated pest and disease management is a key of commercial mango cultivation.

Plant protection measures before the onset of rainy season

Cultural practices after the end of harvesting and before the rainy season found helpful for minimising the major outbreak of pest and diseases after the rainy season. It is essential to remove and destroy affected and fallen fruits due to fruit fly and fruit borer infestation. It is also essential to destroy affected shoots due to shoot borer infestation along with larvae, dead and weak branches as well as un-fruited panicles in order to reduce the inoculum of various diseases. Avoid overcrowding of the laterals and foliage as it develop the favourable microclimate for

pest and disease build up. It also prevents the penetration of the pesticide spray which invites the pest resurgence due to residual population. Therefore, proper thinning/ centre opening should be done and kept trees open and well aerated. To avoid dieback, It is recommended to spray 1% Bordeaux Mixture or 0.25 % Copper Oxychloride or 0.3 % Hexacanozole on the whole tree. In severe condition, it is recommended to cut the 6 to 8 cm below the affected branch and apply bordeaux paste to cure the wound.

Plant protection schedule for integrated pest and disease management (IPDM)

Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli has done a lot of research to standardizes the schedule of IPDM for control of pest and diseases in Mango at various research stations in mango growing belts by using different chemicals having label claim and available in local market. Schedule is developed by considering the period of occurrence of pest and diseases, their life cycle, damage intensity, residual level, combination feasibility. Hence it is very effective and economical. (Table 3)

Protection from mango fruit fly–Trap and bagging

Though Alphonso is comparatively tolerant to fruit fly and stone weevil, for the control of fruit fly Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli has recommended to use "Rakshak Trap" containing Methyl eugenol lure @ 4 traps ha^{-1}. Similarly, for the production of export quality fruit, paper bags were found most effective not only against fruit fly and stone weevil but also for the production of spotless fruits. Hence, after the drop at marble stage fruits should be covered with 20 cm x 24 cm good quality news paper bags for production of spot less fruits for export purpose. (Plate 10)

Table 2. Profitability of production at total cost of mango by adopting PBZ technology. (₹ ha^{-1})

Sr. No.	Particulars	Adopters (N=60)	Non Adopters (N=60)
1	Yield (t)	4.70	2.92
2	Gross returns (₹)	2,51,450	1,19,720
3	Cost of cultivation at		
	a) Cost–A	57,005	29,265
	b) Cost–B	1,09,444	59,434
	c) Cost–C	1,22,373	69,561
4	Net income at		
	a) Cost–A	1,94,445	90,455
	b) Cost–B	1,42,006	60,286
	c) Cost–C	1,29,077	50,159
7	Benefit cost ratio	2.05	1.72
	Percent increase in Net income of PBZ adopters over non adopters	157.33	-

Precautions to be taken while spraying

Surveillance study showed that the adult population was naturally declined sharply from May to November and usually nymphal outbreak of mango hopper noticed during November-December. The nymphal population should be monitored regularly and if the population is increased in spite of neem products application, then recommended synthetic pesticides should be used. The fungus *Verticillum lecanii* was also observed effective to some extent, hence may be tried during late rainy season so that it will develop on residual adult population due to high humidity and cloudiness, culture will develop naturally in the garden. After monitoring if spraying is required, targeting the hoppers, other pests intensity may also be taken into account and use of pesticides which were effective for both pests.

It is essential to apply spray before 11.30 am and after 3.30 pm. While spraying it should be done from inside and then outside, from top to bottom. Drop size during spraying should be micro and most importantly avoid harmful pesticides. Due to climatic fluctuation, trees were flowering twice or thrice in a season. Hence it is recommended to spray on tree as per the schedule after flowering but it is also advocated to take one single spray in whole orchard after 50 percent trees flowered completely.

Point 4: Integrated management practices for fruit retention and quality improvement (Jan - March)

In Konkan region, flowering usually occurs in three flushes in the season in Mango. On a full-grown mango tree, about 1000 panicles occur depending on the variety. Each panicle produces 500 to 6000 flowers, out of which the hermaphrodite flowers range from 10 to 50 only. Under normal conditions, the average % of hermaphrodite flowers in Alphonso, Ratna, Kesar, Sindhu and Goamankur is 13, 27, 30, 35 & 25 per cent respectively. Hence in mango, it is essential to use integrated management practices for retention and development of quality fruits.

Flowering and fruti setting

Alphonso mango is reported as shy bearer by many researchers. Each panicle of Alphonso mango tree on an average bears 1000 to 2000 flowers. On an average five to eight fruits (at pea grain stage) usually set per panicle in Alphonso mango and as per research observations only one fruit is retained for every 6 panicles. Out of total hermaphrodite flowers in a panicle, 20 per cent drop due to lack of floral parts, 20 per cent due to insect / pest attack and rest 40 to 50 per cent due to failure in pollination. Hence, it is essential to use recommended technology of Dr. B. S. Konkan Krishi Vidhyapeeth, for retention of remaining fruits and to increase the quality and quantity of fruits at harvest.

Retention of fruits and development

Retention of fruits is depending on healthy nutrition, congenial environment and no water stress for completing metabolic activities. Hence it is essential to protect fruits from biotic and abiotic stress during their growth phases by giving protective irrigation, supply of nutrient and growth hormones externally. If the deficiency of Auxin gets developed during flowering phase it leads to abscission (yellow colour ring). For retention of fruits, application of 2 sprays NAA 20 ppm or 2, 4-D 10 ppm is recommended, first at pea grain stage while second

Table 3 Mango Blossam protection schedule

Sr. No	Time of Spray	Recommended Insecticides	Quantity of pesticide per 10 lit.	Remark
1	First spray at vegetative flush after monsoon	Deltamethrin 2.8% EC or Monocrotophos 36% EC	9 ml 15 ml	It gives protection from mango hoppers which were occurred after rainy season on new flush.
2	Second spray at bud burst stage	Lambda Cyhalothrin 5% EC	6 ml	For Powdery mildew mix Hexaconazole 5 % EC 5 ml or Sulphur 80 % WP at 20 gm per 10 lit of water. In cloudy weather condition for management of Anthracnose mix Carbendazim 12 % + Mancozeb 63 % at 10 gm per 10 lit of water.
3	Third spray 15 days after 2nd spray	Imidachloprid 17.8% SL	3 ml	At the time of 3rd, 4th and 5th spray for management of Powdery mildew add Hexaconazole 5 % EC 5 ml per 10 lit of water. If Hexaconazole is not available use Sulphur 80 % WP at 20 gm per 10 lits of water. In cloudy weather condition for management of Anthracnose mix Carbendazim 12 % + Mancozeb 63 % at 10 gm per 10 lit of water.
4	Fourth spray 15 days after 3rd Spray	Thiamethoxam 25% WDG	1 gm	
5	Fifth spray15 days after 4th spray	Diamethoate 30% EC Or Lambda Cyhalothrin 5% EC	10 ml 6 ml	
6	Sixth spray 15 days after 5th spray if necessary.	Insecticide recommended for 5th spray but not used for the 5th spray	-	If Mango hoppers crossed ETL level (Need-based spray)

after 15 days.

During fruit setting and development of fruit, tree required nutrients. It is difficult to supply nutrient through soil followed by irrigation. Hence It is recommended to give nutrient sprays of KNO_3 one per cent at pea stage for effective control of fruit drop, at marble stage for increasing size and at egg stage to improve qualitative parameters.

Protected irrigation near the trunk of the tree of 100 liter twice in a week or 200 liter once in a week at weekly interval starting from pea stage to egg stage is also advocated. Through research experiments, it was observed that irrigation helps to improve the metabolic processes resulting in translocation of nutrients, increase in rate of photosynthesis and fruit enlargement. It is also observed that protective irrigation also helps to reduce spongy tissue incidence in Alphonso mango fruits.

Control of recurrent flowering

Recurrent flowering has been noticed in Alphonso mango, is characterized by emergence of new flowering shoots at base of previously emerged panicles-bearing developing fruits, diverting nutrients. Fruits on old flowering shoots drop down due to formation of abscission layer on the old panicles bearing fruits. This type of recurrent flowering occurs when there is low temperature for prolonged period after earlier flowering and fruit set. The Alphonso variety is more prone to this malady (Burondkar *et al.* 1999*)* Application of GA_3 inhibits the recurrent flowering in mango as GA_3 is antagonistic to flowering. So one spray of GA_3 50 ppm at full bloom stage or pea grain stage has been recommended on whole tree for controlling recurrent flowering in Alphonso mango to save precious early crop.

Use of Amrashakti as a foliar nutrient supply

Dr. B. S. Konkan Krishi Vidyaapeeth, Dapoli has recommended to undertake three, multi nutrient Amrashakti sprays containing 0.5% (Urea, SOP, SSP each) + 0.25% ($ZnSO_4$, Borax, $CuSO_4$ each) + 0.01% (Sodium molybdate), first spray at bud break, second on full bloom inflorescences and third at egg size fruit of Alphonso mango along with recommended dose of fertilizers in lateritic soil of Konkan to obtain higher yield.

Other management practices to improve quality of fruits

Management practices like timely removal of dried flowers, thinning of small size fruits, inserting dried leaf in two fruits to avoid bruising are playing an important role for enhancing the quality of fruits. Shaking of branches with a bamboo stick can be done to make the inflorescence clean. This shaking operation be done two to three times in a season. An individual fruit development on a panicle should be encouraged by thinning the smaller fruits after they have attained a size of marble stage. Similarly a fallen mango dry leaf is inserted between two fruits to avoid contact and bruising (Plate 11).

Point 5: Post-harvest pruning of branches for improvement in photosynthesis (carbohydrates) and control of vigor (April - May)

Mango tree after giving yield required a rest. New canopy get developed with a flush in the month of June with the start of new cycle. Hence it is very much important to prune the old unwanted branches i.e. weak, dried, overcrowded, low hanging branches. This activity will help for better penetration of light and to increase photosynthesis rate for more carbohydrate accumulation.

Table 4. Studies on use of potassium under integrated technology adoption for improving yield and fruit quality of Alphonso mango.

Particular	No of fruit retained per panicle at harvest	No of fruits tree^{-1}	Yield (kg tree^{-1})	Yield (t ha^{-1})
Control	0.25	166.89	41.0	4.10
Modified Fertilizer dose under five point technology	0.47	323.66	78.5	7.85
SE	0.015	20.55	3.08	0.31
CD @ +2	0.045	61.14	9.25	0.93

Importance of light penetration

Mango tree bear fruits on the branches found on periphery. Sometimes it also observed on the branches were active leaves are more due to presence of light. Quality and quantity of light play an important role in photosynthesis. It is observed that light intensity up to 1000 PAR reported maximum photosynthesis under Konkan agro climatic condition. It was also observed that maximum photosynthesis and other metabolic activities were maximum up to 1.00 pm afterwards starts declining. Hence intercultural operations like irrigation, spraying during morning hours as well as penetration of light in internal part of tree canopy has maximum importance.

Pruning of branches for maintaining canopy

Mango tree has umbrella shape canopy. To maintain the shape of tree, pruning is done immediately after harvest & not more than 15 to 20 per cent biomass should be removed at a time - yield decline. If one can see the structure of internal branches and arms from long distance, tree is healthy, penetration of light is good and no major pruning of branches is essential. (Plate 12) To maintain such type of tree structure various types of pruning methods are recommended by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

Opening of center in V shape

Mango tree after harvest need to be pruned in V shape at the center checking the direction of sun to promote maximum entry of light towards the center. This operation will reduce the tree height significantly. Every branch of tree will like to grow in upward direction with the principal of apical dominance. But it is also essential to maintain the height as per the distance between two trees as height should be 75 to 80 % of the spacing. If the tree height is more then it will naturally affect photosynthetic activity leading that branch to induce vegetative growth. Hence it is essential to prune one to two season growths along with shooting spur after harvest to check the height and side growth.

Cutting is done one inch below the node to allow two to three branches from bud on the intermodal area of the twig. These branches has wide crotch angle suitable for more photosynthesis. (Plate 13)

Skirting

Mango fruit bear a weight of 200 to 350 g. On the basis of number of fruits on the branch, the branch gets bend towards the land. If the weight is more sometimes get break from the joint. Hence support is required during bearing phase. If such branches are not pruned then they show vine like growth. Hence skirting is practiced. Such branches are cut at a portion from where they started downward inclination. New branches are allowed to grow towards sky ward direction. Removal of low hanging branches near ground will felicitate fertilizer application and easy controlling of weed near root zone.

Window opening

Window opening operation is done with overcrowded branches. Pruning of tree is done to open up the canopy restricting the penetration of sprays and to increase the availability of light inside the canopy for better photosynthesis. Hence immediately after harvest or immediately after heavy rain, window opening is done. While removing the branch having 5 to 10 cm diameter, first cut up to 10 % is given on lower side of branch, so that a smooth cut from top is possible. This avoids bark splitting.

Hygiene

Removal of diseased or dead branches acting as a source of infestation and multiplication is essential immediately after harvest, after rain and after control of infestation. Loranthus is also removed from time to time.

Maintenance after pruning

It is essential to apply Bordeaux paste on wounded portion and spray 1 % Bordeaux mixture on new flush to protect it from dieback disease. Collection of all the fallen branches and timely disposal will be helpful to avoid entry and multiplication of stem borer in the orchard.

Economics of Five point integrated technology approaches for doubling mango production

Alphonso Mango fruits fetch premium price for season's early crop. Rate of mango will remain fluctuating depend upon the import of mango fruits from various part of the country. Approximately a tree with 10 to 15 years of age is giving 300 to 350 fruits i.e. 6 to 7 boxes of 4 dozen each. Approximately cost of one dozen fruit (Rs. 100 to Rs. 150) is required as expenditure for each point of integrated technology described above for a tree. Hence adoption of five point integrated technology approach will be sustainable and helping farmers for doubling mango production.

Profitability adopting PBZ technology

The profitability in rainfed mango production is given in Table 2. It is revealed that the per hectare cost of

production was ₹ 1,22,373 and ₹ 69,561, gross returns of ₹ 2,51,450 and ₹ 1,19,720 with benefit cost ratio of 2.05 and 1.72 in PBZ adopter and PBZ non-adopter category, respectively. Comparing cost and gross returns in both the groups it was observed that total cost inserted by 75.78 per cent, however gross returns enhanced by 110.03. This was mainly due to advantage of start of early marketing in mango. Accordingly, the net returns estimated at cost A, cost B and cost C were more than double in PBZ adopter category over non adopter category. Better productivity and price advantage grabbed in the beginning of season, were the benefits to the PBZ adopter category which resulted into higher per hectare income. As a whole, the net returns were 157.33 per cent higher for PBZ adopters than to PBZ non adopters.

Rejuvenation Technology

Rejuvenation is the process of pruning and after pruning, management of the plants to make them productive by utility the existing root system, which mean restoring the productivity by utility the existing root system, which mean restoring the productive capacity of the fruit trees.

Advantages of Rejuvenation

- Increase the productivity and economic age of plant.
- Convert the low yielding and inferior varieties/ seedling origin trees into superior and high yielding trees.
- Exploit the better root system of a plant who has survived in adverse soil and climatic conditions.
- Lessen the time reduction in gestation period/ suvenile period.
- Increase the orchard income.
- Lessen the incidence of diseases and pests.

The following technologies have been developed by the University.

1. March and October are appropriate seasons for pruning in Konkan region for rejuvenation.
2. Severe and rigorous pruning as suggested by Israel experts in mango orchard above 20 years age is harmful for Konkan conditions. A gradual pruning in two or three phases as suggested by the university is appropriate in Konkan region.
3. After pruning the appropriate canopy development and aftercare to avoid stem borer infestation are critical points in rejuvenation. The advice given by Israel experts helped to develop appropriate plant architecture in Alphonso rejuvenated orchards.
4. For maintenance of canopy, continuous and non-selective pruning is detrimental. For induction of flowering, selective maintenance pruning is essential.
5. The fruits of rejuvenated plants are better with respect to quality and taste. Operations such as bagging can be done to protect the fruits from adverse climatic conditions as well as from pest and diseases. The operations like manure and fertilizer application, spraying for plant protection, harvesting becomes much easier.
6. After rejuvenation, the low density orchards planted at 10 x 10 m spacing can be converted into high density orchard by inter planting of additional mango plants at 5 m x 5 m.

Dissemination of Technology

Demonstrations of technology of rejuvenation as well as high density planting were simultaneously organized on the farmer's field in Ratnagiri and sindhudurg districts. During the "Center of excellence for mango" project tenure 2010-11 to 2014-15 more than 5oo demonstrations in most than 108 villages by pruning 1402 plants have been completed. Number of farmers were 202 and total number of trees puruned were 1402.

Total 240 training cum awareness programmes were organized at village level through which more than 6,900 farmers have been trained regarding the technology developed under the project in Ratnagiri and Sindhudurg district. Particularly in Konkan region age of mango orchards is bet when 40 to 60 years. Alphonso mango get a low yield, because of old age orchard, difficult to manage the insect-pest control and other related management of Alphonso mango.

Comparative cost of production of rejuvenated and non rejuvenated mango orchard

Per hectare comparison of cost of cultivation of rejuvenated and non rejuvenated orchards is worked out and presented in Table 5.

From Table 5 it is revealed that per ha total cost (Cost C) of production of non rejuvenated orchard was ₹ 1,29,401 as against ₹ 1,54,006 of rejuvenated orchards at overall level. At Group III i.e. about 7 years after rejuvenation it was ₹ 2,21,346. Per hectare yield of non rejuvenated orchardwas 32.24 q. and in rejuvenated orchards at overall level it was 33.50 q. In fully matured rejuvenated orchard it was 61.55 q. After rejuvenation, per hectare incremental yield was 29.31 q. and incremental net returns were 53,189. Similarly, per hectare saving in expenditure on labour of spraying and harvesting of fruits was 32.10 per cent.

The gross returns of non rejuvenated orchard were ₹ 1,53,076, while in rejuvenated orchard it was ₹ 2,98,210 in third group. The benefit cost ratio was 1.18 at non rejuvenated orchards as against 1.35 at rejuvenated orchards. Per quintal production cost of non rejuvenated orchard was ₹ 4,014 as against ₹ 3,596 in rejuvenated orchard. Thus it is clear that as age of rejuvenated orchard increases the productivity also increases.

Case study

Studies on use of potassium for improving yield and fruit quality of Alphonso mango was conducted at CES Wakavali in the year 2001, 2002 & 2003. 30 year old 54 Mango trees were marked for conducting experiment. Various nutrient treatments were followed by common treatment like PBZ application, plant protection, Control of fruit drop and quality improvement, canopy management. Results of the experiment are as under.

Experiment results showed doubling of yield, hence mass demonstration was conducted at Wakawali on 500 mango trees and same was adopted by many farmers in Ratnagiri and Raigad Districts in Konkan with spectacular success. Result of the five important key technologies adopted and demonstrated at Central Experimental station Wakavali are summarized below (Table 3)

Conclusion

Poor mango orchard efficiency (2.5- 3.0 t ha^{-1}) and high annual fluctuations in mango crop, due to "on" and "off" year of bearing habit, are considered as long standing constraints in sustainable mango farming in Konkan. Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, since its establishment in 1972, has been carrying out all round, multidisciplinary research on various aspects of mango, to overcome these constraints. Over the past 45 years, university has developed and recommended more than 150 individual technologies for the yield and quality improvement in mango, From bunch of several recommended technologies, five key integrated technologies, which are most crucial ,high impact generating, and cost effective, were identified and clubbed into five points and scheduled to fit into annual mango growth cycle in Konkan. These include: First, tree-specific, need-based, timely followed integrated nutrient management at the onset of monsoon i.e. June. Second, for ensuring regular and early flowering, tree-specific optimum dose of Paclobutrazol, applied at right time adopting right method during July-Aug. Third, scrupulously following university recommended plant protection spray schedule, starting from post-monsoon pre-flowering till setting of marble stage fruits ie.e Nov. to Mid Feb. Fourth, need-based sprays for foliar feeding of nutrients and growth regulators and 5-6 irrigations at weekly interval, starting from peanut stage, to ensure good fruit set and quality of fruit (Feb.

Table 5. Comparative per hectare cost of production of non-rejuvenated and rejuvenated mango orchards (Figures in ₹)

Sr. No.	Particulars	Non Rejuvenated orchards (N=60)	Rejuvenated orchards			
			Low (N=17)	Medium (N=29)	High (N=14)	Overall (N=60)
1.	Total Cost	1,29,401	1,30,542	1,67,903	2,21,346	1,54,006
2.	Yield (q)	32.24	11.82	32.67	61.55	33.50
3.	Rate (q^{-1})	4,748	4,530	4,687	4,845	4,679
4.	Gross returns	1,53,076	53,545	1,53,124	2,98,210	1,56,747
5.	Net returns	23,675	-76,997	-14,779	76,864	2,740
6.	BC Ratio at Total Cost	1.18	0.41	0.91	1.35	1.02
7.	Cost per Quintal	4,014	11,044	5,139	3,596	4,597

to March). And fifth, post-harvest canopy management, adopting recommended tree specific pruning techniques for harnessing maximum sunlight for assimilation of maximum food through photosynthesis during May. Field demonstration of these five integrated key technologies have shown that these could form the basis for doubling the farmers' income in Konkan region.

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