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Sustainable Management of Mango Trees for Better Quality

Vidyasagar Chandrasene koli [1]

[1]M Tech BSC Chemistry ABM DBM (Farmer)

Abstract - Optimum supply of macro and micronutrients is of critical importance in improving the yield and quality of horticultural crops. Alike, the quality and yield of mango plants significantly increase by balanced application and uptake of macro and micronutrients. However, soil type and characteristics are important factors that directly influence the bio-availability of these nutrients to the plants. In addition, variability in climate has an impact on mango yield in the current scenario. Many scientists have found that mango cultivation in saline soils is a major obstacle to achieving the desired yield and improving quality. Overdose of fertilization is the major factor for the development of saline soils; furthermore, rise in climate temperatures is also a major factor. Therefore, to overcome this problem, nutrient management and the use of balanced fertilizer are the important factors to be controlled. Thus, this review focuses on the performance and importance of essential macro and micronutrients to improve the yield and quality of mango fruits. To understand the effective use of macro and micronutrients, the positive and negative impacts of the nutrients are explained. It is suggested that analyzing the soil, mango fruits, and mango plant leaves for their nutrient status can be useful to formulate fertilization strategies for higher fruit production and quality. Research and development, along with agricultural extension, should focus more on introducing genetically effective mango varieties to improve nutrient and water utilization efficiency.

1. INTRODUCTION

Noteworthy milestones have been accomplished in production and productivity of fruit crops in the country. Mango is the most important crop in the country accounting for 38 per cent of the total area allocated to fruits, i.e., 6.1 million ha during 2008-09 contributing to 18.6 per cent of the total fruit production in the country. In production, mango ranked second after banana with 68.47 million MT. The area under mango has been steadily increasing over the period from 2009-12 to 2016-17, the increase being 46.5 per cent over and above the base area of 1.576 million ha. The production, however, has not kept pace with the area expansion and has been fluctuating over the years with overall increase of 27 per cent only during the corresponding period. The total mango production was the highest during 2011-12 (13.997 million MT) with 6.3 MT productivity which is quite low as compared to Brazil and Mexico. There is a need to improve mango productivity along with quality in order to ensure competitiveness of Indian mangoes in the global scenario. With the WTO regime in place and our country being also the signatory, concerns about food safety and quality, environmental protection, worker safety and welfare have also gained importance. Thus, it is desirable to set up control and compliance systems for mango production. In this context, it is imperative to pay attention to the parameters of production practices that require minute attention at different stages of production, handling and distribution for trade. There are also different systems and standards available for control measures in value addition through processing of food meant for human consumption that need to be integrated. The areas, where appropriate control measures are to be strengthened, need to begin at orchard level during the pre-harvest stages to ensure sustained supply of produce of the desirable quality.

Although grade standards on size, shape, colour and local preferences are available for majority of the mango varieties produced, marketed and consumed in India, their quality in terms of maturity standards, residues of pesticides and other contaminants, microbial loads, etc. have not been adequately addressed. Good Agricultural Practices (GAP) has a bearing on these parameters. In other words, a farm producing mangoes following GAP either for direct consumption or for processing would have an advantage in terms of safety and quality over the other farms. Thus, these practices would add value to the produce. In India, agricultural practices are highly localized occupations and display a lot of variability and variety preferences prevail across regions. Further, with the opening up of the world market and creation of quality infrastructure there is a flow of trade across regions. It is, therefore, necessary to define and assign certain common minimum standards for production of mango in the country to win the confidence of the consumers within the country and outside and facilitate trade for sustaining livelihood options of farming communities.

1.1 Concept of Good Management Practices

Before the concept of Good Agricultural Practices (GAP) has evolved during the recent years in the context of a rapidly changing and globalizing food economy and as a result of the concerns and commitments of a wide range of stakeholders about food production and security, food safety and quality, and the environmental sustainability of agriculture. These stakeholders include governments, food processing and retailing industries, farmers and consumers, who seek to meet specific objectives of food security, food quality, production efficiency, livelihoods and environmental
benefits in both the medium and long term.

1.2 Aims & Scope of Good Management Practices

According to the Food and Agriculture Organization (FAO), GAP is the application of available knowledge to addressing environmental, economic and social sustainability for on-farm production and post production processes resulting in safe and healthy food and non-food agricultural products. Many farmers in developed and developing countries already apply GAP through sustainable

agricultural methods such as integrated pest management, integrated nutrient management and conservation agriculture. These methods are applied in a range of farming systems and scales of production units, including as a contribution to food security, facilitated by supportive government policies.

Presently, GAP is formally recognized in the international regulatory framework for reducing risks associated with the use of pesticides, taking into account public and occupational health, environmental and safety considerations. The use of GAP is also being promoted increasingly by the private sector through informal code of practices and indicators developed by food processors and retailers in response to emerging consumer demand for sustainably produced and wholesome food. This trend may create incentives for the adoption of GAP by farmers by opening new market opportunities, provided they have the capacity to respond.

1.3 Benefits of good agricultural practices

- Development of basic infrastructure at the farm level
- Build up culture for good agricultural practices by the farmers
- Uniform approach across farms regardless of their sizes
- Increased awareness among the farmers as well as the consumers about the need for consumption of good quality and safe food
- Traceability through complete integration of food chain

2. Grower's Record

2.1 Type of farming (Reco)

It is to be recorded that what type of farming is done by farmer, i.e., cooperative, contract, lease farming, individual farmer, group farming activity or as a tenant or self-cultivation or on contract basis.

2.2 Capability (Minor)

Grower's accomplishment in farming, technical background in fruit production, the skills acquired and knowledge support available from Govt. or any other competent organization or individuals, formal education or experience, etc. to be known.

2.3 Record maintenance (Major)

Proper record should be maintained by grower about crop production, sequence cropping, crop rotations, cropping systems, cropped area, cultivation sheets for the current and previous growing seasons, etc. in the corresponding field.
GAP is nothing but self-auditing by the grower to make sure that all genuine practices are adopted as per the standards. For certification by the certifying agencies, it is very important to check the records for purchase, supply, operations, instructions and the events that are happening every now and then. Record keeping is not only for auditing but also for better understanding about the operations that are to be carried out over a period of time without omission. It helps in better farm management and to indicate operations that are vital for successful farm management.
The major must for this are:-

a) The farmer should undertake a minimum of one self inspection per year against the GAP Standard and,
b) The internal self-inspection should be documented and recorded.

2.4 Internal evaluation (Major)

The farmer/society/cooperative body should undertake internal self-inspection on scheduling of crop production practices and exercise necessary supervision in their adoption.

2.5 Planting materials (Major)

Seedlings, saplings, graft and buddings and cuttings should be procured from a certifie source and it should be specified if these have any special quality with reference to resistance to pests/diseases, nutritional quality, etc. It is required to verify the plantation is grown from seedlings or vegetatively propagated material for stability in the quality of the produce. Necessary documentation should be maintained to verify the produce, physical or any other characteristics.

2.6 Nursery

Establishment of poly and net house

Usually 3-4 months (July-September) are suitable for propagation of mango in northern India but with the use of automatic/semi automatic polyhouse and net house structures

Table 2.1 Poly house made of poly carbonate sheets and UV stabilized polythene sheet

Size of structure -	10 x 15 m
Maximum height of structure	2.5 m (Round shape)
Fitted with temperature and humidity controllers	Fully automated
Ideal temperature 30±20C	30±2^0 C
Humidity	80-90 %

Shade net house

Size of shade house	40.0 x 20.0 m
Height of shade house	3.0 m
Shade in net houses	50 and 75 %
Overhead sprinklers for irrigation	Fully automated

Hi-tech Nursery

Standard size of poly and shed net house for establishment of model nursery

The standard size of poly and shade net house is provided as under.

a. Nursery propagation (Minor)

Necessary documentation should be maintained whether it is primary or secondary nursery, whether raising the seedlings in the open or under protected conditions. Quality control systems *viz*. raised seedbeds, soil solarization, granular application of insecticides, drenching soil surface with fungicides, etc. needs to be recorded.

b. Nursery protection (Minor)
Proper preventive measures against pests and diseases need to be taken and recorded. Propagated planting material needs to be examined against pests and diseases in the nursery before release. Necessary documentation should be maintained to verify the claim.

c. Varieties (Major)
Mango has a large number of known and unknown varieties. Grafted varieties as well as seedling populations are available in the country. In case of mango, same varity is named in different areas by different names. For example, Alphonso is also known as Happus, Totapuri as Bangalora, Banganpalli as Baneshan, Safeda, etc., Bombai as Bombay Green, Siroli etc., Langra as Banarasi Langra, Malda, Dudhia Malda, Telia Malda, Digha Malda, Darbhanga Malda, etc. Standard name need to be documented so that the consumers are not misled. The qualities of the same varity differ in different areas. For example, Dashehari grown in Malihabad, Kakori, Mal and nearyby areas of Lucknow is of superior quality compared to other areas of U.P. as well as other parts of the country. Similarly, Alphonso grown in Ratnagiri area is having unique taste and quality compared to Alphonso of different areas. Similar are the cases with other varieties like Langra, Chausa, Kesar, Benganpalli, Totapuri, etc. As it is a vegetatively propagated plant and there should not be much variation in the quality, the mango varieties behave differently as per the agroclimatic region. Hence, GIS status is granted to different varieties of mango. Recently, GIS status is granted to Malihabadi Dashehari. So, it is essential to properly label the varieties grown in particular region to know the quality of mango and get the maximum price of the product.
Therefore, the major must for this are:-
a) Standard variety name should be mentioned for the marketing of the mango fruits and
b) The origin place of produce should be mentioned so that the quality assurance is acertained.

3. Experimental Procedures

The experiment was conducted on 7 years old, healthy and vigorous and uniformly grown mango trees of cv. Keshar at Krushi karma nursary Murud Tq.Dist. Latur in a Randomized Block Design with Sixteen treatments and three replications with two trees per treatment during the year 2023-24. The trees without any treatment served as control. The PGRs NAA 40 ppm, CPPU10 ppm and CPPU 20 ppm were sprayed thrice at mustard, pea and marble either or at all stages of fruit development. The observations were recorded on fruiting, physioc-chemical parameters and yield.

3.1 Treatment details

Treatment No.	Treatment details	Stage	No.of sprays
T1	Control (Water spray)	M+P+MB	3 sprays
T2	NAA - 40 ppm	Mustard stage	1 sprays
T3	NAA - 40 ppm	Pea stage	1 sprays
T4	NAA - 40 ppm	M+P	2 sprays
T5	CPPU-10 ppm	Mustard stage	1 sprays
T6	CPPU-10 ppm	Pea stage	1 sprays
T7	CPPU-10 ppm	M+P	2 sprays
T8	CPPU-20 ppm	Mustard stage	1 sprays
T9	CPPU-20 ppm	Pea stage	1 sprays
T10	CPPU-20 ppm	M+P	2 sprays

4. Pre Harvest Practices

4.1 Soil preparation (Reco)
Soil for growing crop should be according to norms set out by the NRC/SAU or as per the standard practices. The soil can be brought to good till the planting of crops is across the slope and along the contour and the soil depth remains adequate to hold the root system of crops.

4.2 Inter-culture (Reco)
The root system should receive adequate oxygen and compaction and erosion of top soil are avoided. The interspaces should be free from weeds and signs of soil compaction.

4.3Weeding (Major)
Safe pre-sowing and post-sowing weedicides should be used. Mechanical weeders or human labour can also be used for weeding.

4.4 Planting density (Reco)
The planting density should be adequate for optimum utilization of land, solar energy and wind movements.

4.5 Facilitation of inter-cultural operations (Reco)
Inter-cultural operations should be carried out effectively. It is required to facilitate intercultural operations in the rows to put down weed growth and provide mulch and aeration to root system.

4.6 Manures and manuring
a. Compost preparation (Reco)
The compost used should have the nutrient content as per the guidelines given by the national bio-fertilizer production centres.

b. Farmyard manure and farm wastes (Minor)

The soils should be enriched with adequate organic matter. Farm wastes carrying pests and diseases should be put deep into the soil. The farmyard manure should be dry and fully decomposed. Usage of cow urine as manure is allowed. Sheep and poultry manure, if used, should be adequately decomposed and are devoid of harmful microorganisms. Livestock manure can be a valuable source of nutrients, but it also can be a source of human pathogens if not managed correctly. Proper and thorough composting of manure, incorporating it into soil prior to planting and avoiding top-dressing of plants are important steps toward reducing the risk of microbial contamination.

c. Green manures (Reco)
The green manures should be used to improve soil health.
d. Bio-fertilizers (Minor)

The bio-fertilizers can be applied for their positive effect on the soil fertility status and up take of nutrients.

e. Sludge (Major)
The use of raw municipal sludge is prohibited for use in mango cultivation.

4.7 Irrigation

a. Water requirement (Major)
The water requirement for the crop should be properly applied. It should be based on the evapo-transpiration studies.

b. Quality of water for irrigation (Minor)
The water quality for the use in orchard should be good, free from excess carbonates, bicarbonates, chlorides, etc. Irrigation water shall conform to IS 11624. Ideally, water used for irrigation or chemical spray should be free from pathogen. However, potable water or municipal water is not feasible for extensive use for crop production. Hence, surface water used for irrigation should be quarterly tested in laboratory for pathogen. Farmers can filter or use the settling ponds to improve water quality.

c. Source of water (Minor)
The source of water should be dependable and sustainable.

d. Irrigation in young and non–bearing orchards

Age (year)	Interval between two irrigation (Days)			
	Winter Season		Summer Season	
	Heavy soil	Light soil	Heavy soil	Light soil
1	6-7	4-5	4-5	2-3
2-3	10-11	8-9	8-9	6-7
4-5	14-15	12-13	10-11	8-9

D.Water harvesting and conservation (Reco)
Rain water harvesting and other water conservation techniques should be practiced in the orchard for use as per requirement. Drip irrigation, sprinklers, etc. should also be used for water conservation wherever possible.
e. Maintenance (Minor)
Irrigation equipments should be maintained and calibrated as per guidelines provided by the manufacturer.
f. Use of sewage water (Major)
Untreated sewage water should not be used in the mango orchard.
g. Prevention of water from undesirable sources (Major)
Flow of water into the fields from undesirable sources like municipal land-fill areas, hospital and industry waste dump areas, etc. should be prevented.

4.9Drainage System

a. Permeability and runoff (Minor)
The permeability status of the soil should be assessed as run off of rainwater may cause leaching of nutrients or flocculation of soil particles. Soils should be appropriate for the type of irrigation water.
b. Drainage system (Minor)
There should be facilities for removal of excess water, over ground or underground.
c. Drain water collection and analysis (Reco)
Analysis of drain water should be carried out occasionally and recorded. There should be adequate drainage facilities for subsoil in the case of fruit crops and analysis should be done for the leached nutrients.

4.8 Crop Protection

Pest Control
a. Crop pests and diseases encountered (Major)
The common pests and diseases endemic to the area should be enlisted with their Economic Threshold Level (ETL) during the past three crop seasons.

b. Integrated Pest Management (IPM)

IPM preventive measures (Major)

The IPM practices suggested for endemic pests and diseases should be followed.

c. Soil treatment (Minor)
Soil treatment for endemic pests and diseases should be followed. Summer ploughing and destroyal of crop residues should be carried out at the appropriate time.

d. Cultural methods (Minor)
Appropriate cultural practices should be followed for preventing the build up of pests and diseases. Pheromone traps and other suggested preventive measures should be adopted.

4.9 Chemical (Major)

The applied chemicals should be clearedfor use by the Central Plant Protection and Quarantine Department/Insecticides Board or recommended by Government. Specified preharvest intervals should be followed with correct dosage, date and time of application. Any banned pesticides should not be used. The chemicals used should be as recommended by Govt. agency.

A.Choice of chemicals

- **Targeting the pests and diseases** (Minor)

It should be ensured that the crop protection chemicals applied is appropriate for the target pest/disease.

- **Approved chemicals** (Major)

Only approved chemicals should be used. Any banned chemical should not be used. The pesticide used should be duly billed by the dealer and registered in India for application on mango.

- **Appropriate dosage** (Major)
  The correct doses at appropriate stage of pests/diseases should be applied.

B. Method of application (Major)

The appropriate method and timings of application should be followed.

C. Pre-harvest intervals (waiting period) (Major)

The registered specified pre-harvest intervals (waiting period) should be strictly followed. No harvesting should be carried out if pre-harvest interval (waiting period) of a pesticide spray applied to the crop has not been reached.

D. Record of applications (Major)

Correct record of all chemical pesticides applied should be maintained. The date of application, mode of application, the dose, the application equipment and operator should be recorded.

4.10 Application equipment

a. Equipment used (Minor)

Appropriate equipment should be used for spraying, dusting and soil application.

b. Condition of the equipment (Major)

It should be ascertained that the plant protection equipment used for spraying and dusting crops is maintained in good condition and is calibrated as per requirements or the manufacturer's guidelines. The nozzles and emitters should be in good condition to allow micro fined spray of the pesticides. The equipment maintenance records should be maintained properly.

c. Storage of crop protection equipments (Reco)

The crop protection equipment should be properly stored in secure areas.

4.11 Crop protection product residue analysis

a. Residue analysis (Major)

The residue analysis of the plant protection product on the produce should be made at the time of harvest as per the applicable/ recommended method. The sampling and analysis should be done as per the recommendation.

b. Maximum residue level (MRL) (Major)

Pesticides used should be within the MRL limit. In the event of residues exceeding the specified MRL values the product can not be consumed.

c. Laboratory accreditation (Major)

The laboratory for conducting the residue analysis should be accredited /recognized by a national body for compliance as per ISO-17025 or equivalent standard covering National Accreditation Board for Testing and Calibration Laboratories (NABL) accreditation for the applicable scope of testing.

5. Recommandation for Good Management

5.1 Climate

Mango is very well adapted to tropical and sub-tropical climate conditions and it thrives in almost all regions from sea level to an altitude of 1500m, from The Cape Comorin to Himalayas. However, it cannot be grown profitably on a commercial scale in areas above 600m. Temperature, rainfall, wind velocity and altitude are the main climatic factors which influence the growth, flowering and fruiting behavior of mango. High temperature during flowering and fruit set adversely affect the crop. Fluctuating temperature during flowering season results into emergence of repeated flush (3-4) and fruit set.

Most of the mango varieties thrive well in places where good rainfall (890 to 1,015mm per annum) prevails. However, it can be grown in regions of either heavy (2540 mm) or scanty (254 mm) rainfall.

5.2 Varieties

There are nearly 1000 mango varieties in India. Of these, however, only about 20-25 varieties are grown on a commercial scale in different parts of India. These are as follows.

Andhra Pradesh	Banganpalli, Totapuri, Himayuddin, Suvarnarekha, Allampur Baneshan, Cherukarasam
Karnataka	Alphonso, Totapuri, Mulgoa, Neelam, Pairi
Gujarat	Alphonso, Kesar, Rajapuri, Vanraj
Madhya Pradesh	Langra, Sunderja, Bombai, Alphonso and several seedling types
Maharashtra	Alphonso, Mankurad, Mulgoa, Pairi
West Bengal	Himsagar, Fazri, Kishen Bhog, Langra, Bombai
Tamil Nadu	Banganpalli, Totapuri, Neelum, Rumani, Mulgoa

5.3 Diversity in Mango Varieties

A. East-Indian Varieties

Himsagar

Fazri

Kishenbhog

Bombai

B. West-Indian Varieties

Alphonsho

Kesar

Malgoa

Vanraj

C. North-Indian Varieties

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Dashehari


Langra


Chausa


Amrapali

6. Soil Preparation

Mango is known to grow well on wide range of soil types such as lateritic, alluvial, sandy loam and sandy. Although, it grows very well in medium to high fertile soils, its cultivation can be made successful even in low fertile soil by appropriate and adequate management of nutrition. Very poor and stony soils on hill slopes, however, are not good for profitable cultivation. However, growing mango in lateritic stone is now successful, if its specific technology is adopted. The loamy, alluvial, well drained, aerated and deep soils rich in organic matter with pH range 5.5-7.5 are ideal for mango cultivation. The extremely sandy, shallow, rocky, water-logged, heavy textured and alkaline or calcareous soils are generally not suitable for mango cultivation.

7. Rejuvenation Technique


Over crowded orchard


Deheading of plants


Thinning of new shoots


New canopy development

Precautions during pruning and canopy management operations

1) Large upright branches and trunks should be cut on a slant angle to prevent water sogging on the cut surface with the potential to cause rotting.
2) Large branches and main trunks should be cut off in sections, rather than in one cut, where they could fall onto branches below and damage them.
3) To encourage rapid healing of wounds, make all cuts clean and smooth. This requires good, sharp pruning equipment.
4) The cut end is pasted with Bordeaux paste (10%) so that no infection develops.

8. Result and Discussion

The different treatments of PGRs had statistically significant effect on fruiting characters fruits set per panicle at pea stage, marble stage and number of fruits retained per panicle at harvest. The number of fruit per panicle at pea stage was significantly influenced by different treatments over control.

Physical Parameter

The length of fruit was in the range of 9.17 to10.53 cm. The maximum length of fruit was recorded in T10 (10.53 cm), whereas minimum length of fruit was recorded in control (9.17) On perusal of data, it is seen that the results obtained in respect of fruit breadth were similar to those observed in case of fruit length.

Table 8.1 Effect of plant growth regulators on physical characters and yield parameters of mango fruits

Tr. No.	Treatments details	Average length of fruit (cm)	Fruit number (tree-1)	Average weight of fruit (g)
T1	Control (Water)	9.17	259.22	257.69
T2	NAA - 40 ppm (M)	9.37	307	260.83
T3	NAA - 40 ppm (P)	9.77	338.23	272.01
T4	NAA - 40 ppm (MB)	9.83	283.22	275.23
T5	CPPU- 10 ppm (M)	9.47	335.67	279.51
T6	CPPU- 10 ppm (P)	9.63	362.33	284.38
T7	CPPU- 10 ppm (MB)	10.33	290	295.40
T8	CPPU- 20 ppm (M)	10.07	332.33	284.23
T9	CPPU- 20 ppm (P)	10.37	346.33	285.52
T10	CPPU- 20 ppm (MB)	10.53	300	313.15

Quality parameters

Acidity (%)

It is revealed from the data that the results were non significant. The lowest acidity was recorded in treatment T10 (0.24) while, the highest acidity was recorded in control (0.30).

Total sugars (%)

It is has been found that the different PGRs had not significant effect on total sugars content of mango pulp. The maximum total sugar was recorded in T9 (15.23) and the minimum total sugars was recorded in T10 (14.92).

Reducing sugars (%)

The results were non significant for reducing sugars. The maximum reducing sugars 5.05 was recorded in T9 while minimum reducing sugars 4.60 was recorded in T1.

Table 8.1 Effect of plant growth regulators on quality parameters of mango fruits

Tr. No.	Treatments details	Acidity (%)	Total sugars (%)	Reducing sugars (%)
T1	Control (Water)	0.30	15.02	4.60
T2	NAA - 40 ppm (M)	0.28	15.05	4.58
T3	NAA - 40 ppm (P)	0.26	14.08	4.55
T4	NAA - 40 ppm (MB)	0.28	15.10	4.80
T5	CPPU- 10 ppm (M)	0.26	15.20	5.01
T6	CPPU- 10 ppm (P)	0.24	15.18	4.90
T7	CPPU- 10 ppm (MB)	0.27	15.12	4.99
T8	CPPU- 20 ppm (M)	0.27	15.05	4.92
T9	CPPU- 20 ppm (P)	0.26	15.23	5.05
T10	CPPU- 20 ppm (MB)	0.24	14.92	4.99

9. Conclusion

On the basis of present project work the following conclusion can be drawn, that, there was improvement in fruit retention and yield of mango fruit due to application of plant growth regulators. Application of PGRs (NAA and CPPU) was found to be beneficial for increasing yield of mango. Application of PGRs at mustard + Pea stage were found effective in increasing number of fruit and weight of fruit than single application at any stage. Among the different PGRs and stages of application, CPPU 10 ppm at mustard + pea stage recorded maximum fruit yield 106.00 kg/tree and 10.60 t/ha of mango.

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