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Quality Production of Mango in Coastal Zone of Maharashtra, India

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Abstract

The coastal region of Maharashtra, India especially the two districts *viz.* Ratnagiri and Sindhudurg are famous for best quality Alphonso mango production and known as 'Mango Basket'. The alphonso mango has 80 % lone share in total mango export of India. It is nutritionally accepted due to its characteristic acid-sugar blend, attractive colour, pleasant aroma, superior fragrance, highly appreciable flavour and delicious taste. The alphonso mangoes produced in these two districts are distinctly different from those grown in other parts of the country. Even within these districts, mangoes produced from Deogad tahsil (Sindhudurg district) have strong smell and typical saffron colour. The separate Geographical Indication (GI) has been alloted to Ratnagiri and Deogad alponso. Alongwith these good characters alphonso suffers from physiological disorder 'Spongy tissue'. These differences are because of microclimate and differences in soil characteristics prevailing in the region. This paper includes the research carried out on relationship of nutrient content in fruit with these important aspects.

Keywords: Mango, Alphonso, spongy tissue, nutrient.

The coastal region of Maharashtra (Konkan region) is famous and well known for mango production with an area of about 0.14 million ha and production of 0.29 MT and 2.07 t ha^{-1} productivity. Particularly, the two districts of the region *viz.* Ratnagiri and Sindhudurg are known as 'Mango baskets'.

The fertility status of the soils is one of the most important factor governing the yield and quality of mango. The soil of Ratnagiri and Sindhudurg districts on which mango is grown is mainly lateritic developed from basalt rock by the process of laterization, and is poor in fertility and having low nutrient retention capacity. These have resulted in deficiency of some macro and micronutrients (Pereira *et al.* 1986). The review of previous research indicated the deficiencies of Ca, Mg, Cu, Zn and B (Mahajan 2001).

The yield and quality of mango fruits are dependent on adequate amount and balance of plant nutrient elements in trees before bearing and harvesting (Pathak and Pandey 1978, Thakur *et al.* 1981, Singh and Dhillon 1993).

The research work carried out at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli indicated that only 45 per cent of the farmers are progressive and follow the University-prescribed practices or use higher amount of nutrients, while the others apply low or very low doses of nutrients than the recommended in Ratnagiri and Sindhudurg districts (Kadam 2006, Joshi 2015). It has been observed that the average quantity of manures applied to the orchards was 25.81 q ha^{-1} (25.81 kg plant^{-1}) in both Ratnagiri and Sindhudurg districts (Naik 2005). The use of manures and fertilizers was far below the recommended dose. The use of secondary and micronutrients is sporadic and/or below the required quantity. This results into mining of nutrients by the plants.

Various characteristics like fruit size, colour, shape, taste, shelf life, processing ease etc. essentially depend on supply of micronutrients (Ganeshmurthy *et al.* 2013). Boron, copper, zinc and ferrous are beneficial for improvement of yield and overall quality of fruit (Nehete *et al.* 2011).

Alphonso is susceptible to a particular physiological disorder i.e. 'Spongy tissue'. The occurrence of this disorder was reported first time by Cheema and Dani (1934). Spongy tissue can be referred to as the development of yellowish white corky patches, soft and spongy in nature with or without air pockets,

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accompanied by off flavor in the mesocarp of the fruit during ripening which ultimately deteriorates the quality of fruits. The disorder is only visible when the fruit is cut open in two halves. The quality of mango fruit is very much impaired due to this disorder. The damage varied with weight of fruit, time of picking, harvesting stage, orchard condition etc. The extent of losses caused by spongy tissue ranges from 20-60 percent under the Konkan conditions of Maharashtra State (Limaye *et al*. 1976). This problem is known since long time and various hypothesis have been put forth for development of spongy tissue by different workers, and various remedies have been suggested to prevent the spongy tissue development. The exact cause and perfect control measures are not yet known.

Various characteristics like colour, taste and fragrance essentially depend upon supply of micronutrients. It is reported that B, Cu, Zn, Fe and Mo are essential for improvement of fruit quality.

In view of this, the soil, leaf and fruit samples (fifteen each) were collected from four orchards at different stages of growth, processed and analysed using standard methods. The two orchards were from Ratnagiri and two were from Deogad. The riped fruits were analysed for different quality parameters *viz*. sugars, acidity, TSS and ascorbic acid. The colour of the pulp was measured with colour reader, anthocynin pigments were analyzed with spectrophotometer and fragrant compounds with GC-MS.

Mango pulp parameters

The average TSS, Acidity, reducing sugar, total sugar, ascorbic acid and proteins in mango pulp from Ratnagiri orchards were 18.92^{o} Brix, 0.34 % acidity, 3.44 % reducing sugar, 13.38 % total sugar, 61.78 mg 100 gm^{-1} ascorbic acid and 6.30 % proteins. Those in mango pulp from Deogad orchads were18.32^{0} Brix, 0.31 % acidity, 3.26 % reducing sugar, 14.20 % total sugar, 61.31mg 100 gm^{-1} ascorbic acid and 5.75 % proteins. However, the values for Anthocyanin pigments were 3.58 mg 100 gm^{-1} for mango pulp from Ratnagiri and 10.74 mg 100 gm^{-1} for mango pulp from Deogad (Table 1).

Micronutrient content and colour values of mango pulp and their correlation

The mango pulp in the fruits from orchards of Ratnagiri location showed avrage 294.04 ppm Fe, 16.95 ppm Mn, 12.64 ppm Zn and 30.17 ppm Cu. Whereas the mango pulp in the fruits from orchards of Deogad location had average 1177.70 ppm Fe, 18.53 ppm Mn, 8.88 ppm Zn and 31.80 ppm Cu.

The colour reader shows the colour in terms of L-lightness/darkness, a- yellowness and b- redness. The average L value for colour of mango pulp from Ratnagiri location was 41.22, A value was 19.68 and B value was

Table 1. Quality parameters of mango.

Sr. No.	Parameters	Locations					
		Ratnagiri			Deogad		
		Warwade-1	Warwade-2	Average	Rameshwar	Padel	Average
1.	Total Soluble Solids (^{0}Brix)	18.68 (14.20-25.00)	17.97 (14.00-22.50)	18.32 (14.00-25.00)	19.99 (17.40-23.50)	17.86 (11.80-24.90)	18.92 (11.80-24.90)
2.	Acidity (%)	0.27 (0.16-0.45)	0.35 (0.22-0.74)	0.31 (0.16-0.74)	0.30 (0.17-0.44)	0.34 (0.19-0.92)	0.32 (0.17-0.92)
3.	Reducing Sugar (%)	3.28 (2.12-4.95)	3.24 (2.18-4.23)	3.26 (2.12-4.95)	3.37 (2.71-4.50)	3.35 (2.00-5.74)	3.44 (2.00-5.74)
4.	Total Sugar (%)	12.42 (7.53-15.06)	14.35 (10.50-16.23)	13.38 (7.53-16.23)	16.03 (10.00-23.36)	12.37 (6.57-16.55)	14.20 (6.57-23.36)
5.	Ascorbic Acid (mg 100g^{-1})	59.65 (52.29-75.53)	63.91 (58.10-73.04)	61.78 (52.29-75.53)	61.42 (57.27-63.91)	61.20 (59.76-62.25)	61.31 (57.27-63.91)
6.	Protein (%)	7.86 (6.12-10.31)	4.74 (2.28-7.07)	6.30 (2.28-10.31)	5.76 (3.50-9.98)	5.75 (4.38-7.18)	5.75 (3.50-9.98)
7.	Anthocyanin (mg 100g^{-1})	3.51 (3.42-3.59)	3.65 (3.58-3.72)	3.58 (3.42-3.72)	11.75 (10.93-12.51)	9.73 (9.60-9.87)	10.74 (9.60-12.51)

(The figures in parenthesis indicate range.)

Table 2. Microutrient contents in the fruit pulp of Mango.

Sr. No.	Parameters	Locations					
		Ratnagiri			Deogad		
		Warwade-1	Warwade-2	Average	Rameshwar	Padel	Average
1.	Total Fe (µg g^{-1})	300.92 (144.20-470.80)	287.17 (172.70-75.30)	294.04 (144.20-575.30)	1192.40 (746.00-1482.00)	1163.00 (668.00-1550.00)	1177.70 (746.00-1550.00)
2.	Total Mn (µg g^{-1})	18.47 (14.30-35.50)	15.43 (14.60-17.40)	16.95 (14.30-35.50)	16.85 (16.10-18.20)	20.21 (16.70-25.80)	18.53 (16.10-25.80)
3.	Total Zn (µg g^{-1})	10.70 (2.40-14.10)	14.59 (10.60-21.40)	12.64 (2.40-21.40)	9.04 (4.30-12.50)	8.73 (6.60-12.70)	8.88 (4.30-12.50)
4.	Total Cu (µg g^{-1})	28.15 (24.20-34.00)	32.19 (27.20-39.40)	30.17 (24.20-39.40)	31.00 (28.00-34.80)	32.61 (29.10-37.40)	31.80 (28.00-37.40)

(The figures in parenthesis indicate range).

Table 3. Colour values in fruit pulp of Mango.

Sr. No.	Colour	Locations					
		Ratnagiri			Deogad		
		Warwade-1	Warwade-2	Average	Rameshwar	Padel	Average
1.	L Lightness or Darkness	39.81 (34.36-44.19)	42.63 (36.78-45.85)	41.22 (34.36-45.85)	49.16 (46.33-52.16)	50.23 (47.06-53.36)	49.69 (46.33-53.36)
2.	a yellowness	20.27 (15.68-25.07)	19.09 (15.65-21.90)	19.68 (15.65-25.07)	30.97 (28.43-49.43)	30.51 (29.33-32.93)	30.74 (28.43-49.43)
3.	b redness	25.03 (21.07-27.91)	27.01 (24.38-28.98)	26.02 (21.07-28.98)	67.94 (52.23-75.53)	68.53 (62.66-71.30)	68.23 (52.23-75.53)

(The figures in parenthesis indicate range).

26.02 and the respective values for colour of mango pulp of Deogad location were 49.69 (L), 30.74 (a) and 68.23 (b) respectively (Table 3).

The correlation between micronutrient content of mango pulp and L, a and b values of colour were positive with Fe, Mn and Zn. However, there was no significant relationship with Cu content of the mango pulp and colour values.

Concentration of fragrant compounds in mango pulp

The mango fragrance depends upon the concentration of different volatile compounds *viz*. Monoterpenes, sesquiterpenes,lactones and furanones. There are twenty one compounds identified in mango pulp. The overall concentration of these compounds is higher in mango pulp from Deogad location as compared to Ratnagiri location (Table 4).

Occurrence of Spongy Tissue in relation to nutrient management

This problem is known since long time and various hypothesis have been put forth for development of spongy tissue by different workers, and various remedies have been suggested to prevent the spongy tissue development. The exact cause and perfect control measures are not yet known. In spongy tissue research several studies have been conducted in different parts of the country which gave contradictory results.

The research on area wise distribution of spongy tissue indicated that the occurrence of spongy tissue is higher (41%) in coastal region than in inland area (22%). Different causes of spongy tissue include pathological

Table 4. Concentration of fragrant compounds in mango pulp (ppm).

Sr. No.	Compounds	Locations			
		Warwade-1	Warwade-2	Rameshwar	Padel
1	γ-Butyrolactone	1.337	0.771	3.658	3.178
2	α-Methyl-γ-butyrolactone	0.007	0.020	0.340	0.169
3	d-Valerolactone	0.020	0.005	0.176	0.049
4	γ-Hexalactone	0.320	0.967	1.243	1.923
5	δ-Hexalactone	2.238	2.528	3.504	1.738
6	γ-Octalactone	0.346	1.996	2.430	4.870
7	δ-Octalactone	0.232	0.836	0.676	1.191
8	γ-Decalactone	0.211	0.472	0.940	1.144
	Total_Lactones	4.712	7.594	12.967	14.262
9	α-Pinene	0.238	0.178	0.337	0.122
10	β-Pinene	0.042	0.003	0.000	0.088
11	β-Myrcene	1.013	0.950	0.881	1.269
12	(Z)-Ocimene	61.223	36.921	80.882	86.785
13	(E)-Ocimene	2.712	1.885	1.236	3.565
14	allo-Ocimene	2.409	1.066	1.047	2.436
	Total_Monoterpenes	67.637	41.002	84.382	94.265
15	Longicyclene	0.054	0.065	0.826	0.089
16	Longifolene	1.191	2.347	3.595	4.863
17	Caryophyllene	1.228	1.619	2.218	3.298
18	α-Humulene	0.758	1.096	1.402	2.314
19	Longicamphenylone	0.149	0.176	0.260	0.171
	Total_Sesquiterpenes	3.381	5.302	8.302	10.734
20	Mesifuran	6.211	6.211	16.899	7.399
21	Furaneol	2.990	2.990	5.030	5.581
	Total_Furanones	9.201	8.261	21.929	12.979

reasons, varietal susceptibility, biochemical changes etc. The high soil moisture increased the susceptibility of fruits to spongy tissue incidence (Joshi 1975).

The relationship of nutrient management with spongy tissue incidence was studied by several workers. Some of them reported that it has no relation with nutrient imbalance. However, Ca, P and K play role in development of this physiological disorder (Subramanyam *et al*. 1971, Krishnamurthy 1981, Gautam and Lizada 1984). The N, P and K content in the leaves of affected fruits were higher while Ca and Mg were lower than the leaves of healthy ones, and N, P, K and Mg content were higher in spongy tissue pulp than in healthy one (Gunjate *et al.* 1979). The single and double pre harvest dips of fruit in calcium solution significantly increased the Ca content and reduced the spongy tissue occurrence in ripe Alphonso fruits whereas there was no significant increase in Ca content by post-harvest calcium dip treatment (Gunjate *et al.* 1979). Spongy tissue also showed lower activities of α-amylase, glutamate dehydrogenase, glutamate oxaloacetate transaminase, peroxidase, catalase, superoxide dismutase, pectin methyl esterase and oxidase (Gupta *et al.* 1985, Selvaraj *et al*. 2000). Higher expression of alcohol dehydrogenase has been

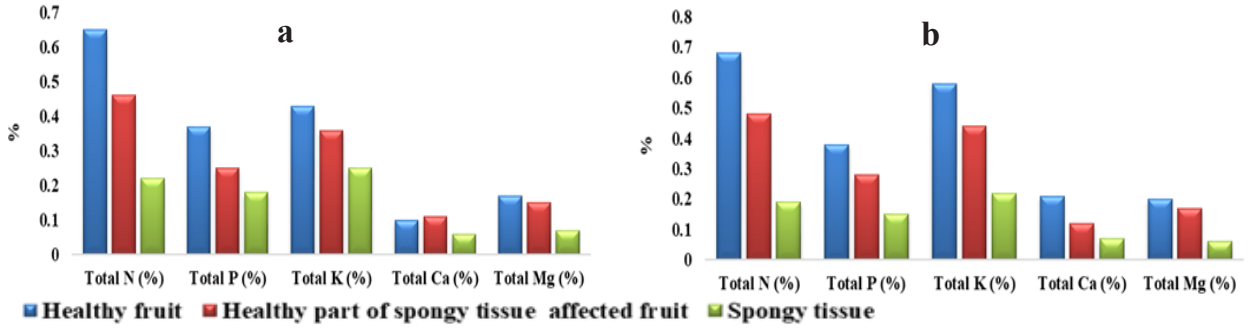

Fig. 1. Comparison between average nutrient content (%) in healthy fruit, healthy part of spongy tissue affected fruit and spongy tissue: (a) 2015-16, (b) 2016-17.

Table 5. Macronutrient content in tissue from healthy mango, healthy tissue from affected fruit and spongy tissue. (Average of two years)

Mango tissue	N	P	K	Ca	Mg
	(%)				
Healthy fruit	0.67	0.38	0.51	0.16	0.19
Healthy tissue from affected fruit	0.47	0.27	0.40	0.12	0.16
Spongy tissue	0.21	0.17	0.24	0.07	0.07

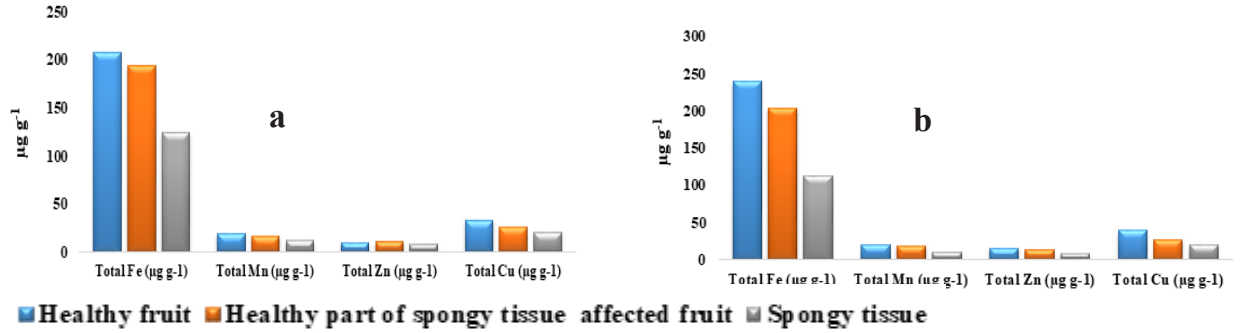

Fig. 2. Comparison between average nutrient content (µg g^{-1}) in healthy fruit, healthy part of spongy tissue affected fruit and spongy tissue (a) 2015-16, (b) 2016-17.

Table 6. Micronutrient content in tissue from healthy mango, healthy tissue from affected fruit and spongy tissue (Average of two years)

Mango tissue	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Healthy fruit	223.78	19.47	12.81	36.55
Healthy tissue from affected fruit	198.80	17.80	12.25	26.50
Spongy tissue	117.90	10.71	7.65	20.33

reported in spongy tissue indicating the anaerobiasis (Vasanthaiah *et al.* 2006). Recently, bacterial infection of spongy tissue is reported by Janaye and Sharma (2008). Lower availability of oxygen may alter the antioxidative systems and ethylene biosynthesis in the affected tissues. Even though the lower activities of antioxidative enzymes were reported its relationship with the membrane peroxidation and ethylene biosynthesis was not studied.

The occurrence of spongy tissue in relation to nutrient management was studied during 2015-16 and 2016-17. There were different fertilizer management treatments including organic, ameliorating and balance nutrition. The results are shown in Table 5 & 6 and Fig. 1 & 2.

The available nutrient status in soil increased after fertilizer application with corresponding increase in nutrient status in leaf and fruit which resulted in higher fruit yield of mango as compared to control i.e. no application of manures and fertilizers. Moreover the highest incidence of spongy tissue was also observed in control (Table 7).

Application of 200 % RDF is responsible for getting higher yield of mango but it also increased the occurrence of spongy tissue, whereas, use of vermicompost decreased the occurrence of spongy tissue.

The soils of mango orchard were moderately acidic. The addition of lime ($CaCO_3$) @ 10 kg tree^{-1} reduced the spongy tissue of mango.

The application of higher dose of potash (2 kg K_2O tree^{-1}) was responsible for reduction of spongy tissue incidence in mango. The analysis of healthy mango pulp, healthy part of affected mango pulp and spongy tissue indicated that there is reduction in nutrient content for almost all nutrients during development of spongy tissue (Table 7).

Conclusion

The research on nutrient management for quality production of mango free from spongy tissue indicated that the colour and fragrance of mango which are the prime quality characters of mango due to which Ratnagiri Alphonso in general and Deogad alphonso in particular has market demand is governed by iron and zinc content of fruit. The reduction in almost all nutrients in mango fruit during development of spongy tissue indicates its relationship with nutrient management. The balanced nutrition, judicious use of organic manures and ameliorating chemicals are the key factors.

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Table 7. Incidence of spongy tissue in mango fruits (Average of two years).

Tr. No.	Treatments	Per cent spongy tissue affected area	Per cent fruits affected
T_1	Control (No fertilizers, No Manure)	43.78	8.13
T_2	Package of practices followed by DBSKKV, Dapoli	35.42	3.13
T_3	Recommended dose + 100 % Extra Recommended dose	38.66	6.88
T_4	2 kg K_2O tree^{-1} (Through SOP) + Recommended dose N & P_2O_5	37.76	4.69
T_5	2 kg K_2O tree^{-1} (Through MOP) + Recommended N & P_2O_5	38.32	2.82
T_6	Soil application of lime ($CaCO_3$) as a source of calcium (i.e. 10 kg per tree) + Recommended N, P_2O_5 & K_2O	23.23	3.44
T_7	3 Sprays of Amrashakti + Recommended N, P_2O_5 & K_2O	31.25	3.44
T_8	Vermicompost 100 kg tree^{-1}	29.93	4.07

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