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STUDY OF MICRONUTRIENT STATUS OF SOIL AND LEAF OF ALPHONSO MANGO IN RELATION TO YIELD

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Abstract- The soil and leaf samples were collected from four mango orchards of Ratnagiri district at five serial stages namely, after harvest of the fruits of previous season, after application of fertilizers, pre-flowering, full flowering and marble stage of fruit for two successive years for the present study. The soil and leaf samples were analyzed for iron, manganese, copper and zinc.

The results showed 'low' status of available iron, zinc in soil at Dapoli and Pangari locations and deficiency of total Fe content in leaf at all locations which needs to be corrected by additional application of them. In general, all the nutrients of soil and leaf were found to be higher at both the Kelshi locations than Dapoli and Pangari locations during both the years.To improve nutrient status of soil and leaf and to enhance the yield at Dapoli and Pangari locations, it is essential to supply higher quantities of micronutrients through soil and leaf.Further, positive and significant correlations of nutrient content of soil and leaf with yield implied them as a measure of forthcoming yield. From these findings, it can be concluded that for enhancing the yield, it is necessary to maintain optimum nutrient contents in soil and leaf.

Keywords- Alphonso mango, Ratnagiri, Soil macro-nutrients, Leaf macro-nutrients, Yield

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Introduction

Mango (*Mangifera indica L.*) is the major fruit crop of India. There are various commercial varieties of mango grown in the country *viz*. Alphonso, Banganpally, Chausa, Dashehari, Langra, Totapuri and Kesar. Konkan region on the west coast of Maharashtra state comprises 'Ratnagiri district' which is famous for Alphonso mango. Due to attractive colour and shape, pleasant aroma and highly appreciable flavour and taste of Alphonso mango, it has tremendous domestic and international market [1]. The district has approximately 0.063 million ha area under Alphonso with production of about 0.12 million tons showing a scanty productivity of 1.9 tons ha^{-1} [2]. In spite of higher coverage of cultivation, the productivity of Alpnonso mango is low. There are several reasons for the low productivity in the Konkan region. It might be due to poor in native fertility and low nutrient retention capacity of lateritic soils on which mango is grown in the district, uncertain environment, alternate bearing tendency of the tree or malnutrition by mango growers resulting from improper nutrient management practices.

In the present investigation, an attempt was made to find out the effect of micronutrients on yield by realizing the seriousness of malnutrition resulting in low yields.

MaterialsandMethods

The Ratnagiri district under present study is geographically situated in latitude of 16.58^0 to 16.98^0 N and longitude 73.18^0 to $73.30\ ^0$E. The collection of soil and leaf samples were collected from four mango orchards located in Dapolitahsil (Dist. Rathagiri) specifically at Kelshi 1, Kelshi 2, Pangari and Dapoli. The first two belong to private farmers while the rest two are owned by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The vary purpose of selecting the diverse owners was to see the effect of varied nutrient management practices on soil and leaf micronutrient status and yield of Alphonso mango. From each orchard, twelve trees were brought under study. Samples of soil and leaf of the selected twelve trees were collected at five serial stages namely after harvest of the fruits of previous season (S I), after application of fertilizers (S II), pre-flowering (S III), full flowering (S IV) and marble stage of fruit (S V) for two consecutive years. The soil samples at 0 to 15 cm depth from fertilizer ring of the tree and the leaf samples situated at fourth and fifth position from terminal bud of recently matured shoots were collected [3]. After collection, the soil samples were analyzed for available micronutrients (Fe, Mn, Cu and Zn) and the leaf samples for total macronutrients (Fe, Mn Cu and Zn) by following standard procedures. The data obtained from analysis were processed statistically by simple correlation coefficients by using the data analysis software SAS 9.3, ICAR - 11601386.

Result and discussion

Micronutrient status of soil

From the data, [presented in [Table-1] it was seen that, during both the years, after application of fertilizer, available Fe content of soil got raised up to pre-flowering stage and then from flowering to marble stage, it declined at all locations with exceptions of Dapoli location in second year and Pangari location in first year. The available Fe content in soil was found to be lower at Dapoli and Pangari locations than that at mango orchards from Kelshi 1 and Kelshi 2 locations. Difference in Fe availability may be due to better nutrient management practices followed by the farmers. As per the soil fertility norms suggested by Raghupathi and Bhargava (1997) [4] for Alphonso mango, most of the samples from both the Kelshi orchards were found to be in 'optimum' class. In case of Dapoli location, the samples were observed in 'low to optimum' class for available Fe while for Pangari location all the samples were found to be 'low' in Fe content in both the years.

Table-1 *Location-wise available micronutrients contents in soil (mg kg^{-1}) at different stages of crop*

Nutrient	Stages	Range	Kelshi 1		Kelshi 2		Dapoli		Pangari	
			I	II	I	II	I	II	I	II
Fe	S I	Min.	37.59	54.33	35.44	45.34	30.25	35.69	25.48	21.90
		Max.	45.66	63.20	44.36	55.46	38.78	41.22	34.55	29.67
	SII	Min.	53.20	65.38	42.03	56.30	39.90	47.70	34.21	33.29
		Max.	61.34	71.25	48.70	64.55	45.17	55.41	40.50	40.74
	S III	Min.	68.69	74.21	37.60	69.62	46.55	53.40	25.46	35.46
		Max.	79.12	81.24	67.70	78.99	56.40	65.49	32.19	44.23
	SIV	Min.	64.21	65.86	48.69	52.18	35.25	33.60	22.35	28.79
		Max.	72.35	75.56	60.17	65.44	49.88	41.22	29.65	35.54
	SV	Min.	60.90	56.50	46.26	49.80	30.11	47.70	20.51	20.90
		Max.	70.87	63.98	58.15	62.13	45.64	55.41	25.45	29.70
Mn	S I	Min.	28.70	34.55	23.56	20.99	22.30	14.45	17.80	15.35
		Max.	29.80	37.65	30.54	27.56	28.70	22.30	23.45	19.07
	SII	Min.	35.46	42.11	25.48	30.22	26.89	23.34	24.31	20.29
		Max.	44.31	50.06	33.40	37.70	34.52	29.88	28.71	26.34
	S III	Min.	40.90	53.33	24.59	46.52	29.08	36.57	20.14	28.99
		Max.	48.68	60.70	36.55	54.91	36.59	42.21	27.81	34.53
	SIV	Min.	33.20	47.67	20.19	37.85	17.60	23.65	16.50	22.44
		Max.	45.35	56.69	30.09	45.90	29.06	34.56	24.92	28.07
	SV	Min.	31.12	35.40	21.46	30.43	15.44	20.09	17.10	16.80
		Max.	40.90	50.24	27.60	40.87	20.10	29.64	22.95	24.35
Cu	S I	Min.	2.87	1.27	2.59	1.00	1.99	0.65	0.41	0.11
		Max.	3.45	1.80	3.10	1.26	2.45	1.21	0.90	0.44
	SII	Min.	3.35	2.55	2.88	3.20	2.30	2.52	0.69	0.60
		Max.	3.89	3.23	3.32	3.47	2.68	2.92	1.12	1.02
	SIII	Min.	3.20	3.35	2.06	2.90	1.70	2.25	0.30	0.57
		Max.	3.41	2.86	2.55	3.40	2.19	2.71	0.85	0.89
	SIV	Min.	2.43	2.29	1.80	2.51	1.53	1.83	0.37	0.40
		Max.	2.98	2.78	2.31	2.96	1.98	2.37	0.78	0.93
	SV	Min.	1.80	2.04	1.20	2.10	1.08	1.30	0.24	0.21
		Max.	2.38	2.36	1.85	2.60	1.49	1.95	0.48	0.66
Zn	S I	Min.	3.20	2.10	2.20	0.80	2.56	1.01	0.74	0.10
		Max.	3.79	2.61	2.65	1.31	3.12	1.34	1.15	0.44
	SII	Min.	4.80	2.22	1.89	2.11	2.40	1.41	0.45	0.80
		Max.	5.30	2.71	2.28	2.49	2.88	1.80	0.98	1.30
	S III	Min.	4.30	1.24	1.50	1.95	2.11	1.24	0.35	0.58
		Max.	4.81	1.72	2.05	2.53	2.71	1.90	0.89	1.12
	S IV	Min.	3.45	1.10	1.33	1.55	1.89	1.10	0.21	0.49
		Max.	4.17	1.44	1.77	2.10	2.38	1.50	0.85	0.88
	S V	Min.	2.66	0.97	1.25	1.34	1.20	0.96	0.25	0.25
		Max.	3.35	1.50	1.58	1.76	1.82	1.33	0.59	0.60

Similar values of the available Fe were also reported by Pawar (2012) [5] in soils of Konkan region.

The data of [Table-1]. showed that the available Mn content in soil at all locations went up after fertilizer application till pre-flowering stage and then went down steadily at all locations and in first and second year with exception of Pangari location in first year. The data related to available Mn content in soil showed its higher status at both the Kelshi locations than Dapoli and Pangari locations which may be result of application of Mn containing fertilizer ($MnSO_4$) and more organic matter (manures) at these locations. In general, all the mango orchards showed 'optimum' status of available Mn content on the basis of critical limits given by Raghupathi and Bhargava (1997) [4]. Similar range of available manganese content was found by Joshi (2012) [6] for the lateritic soils from mango orchards of Konkan region.

From the data [Table-1], it was seen that, the available copper content in soil got increased after fertilizer application and reduced from pre-flowering to marble stage in both the years at all the locations. These observations are in conformity with [7]. In general, higher amount of available copper was observed at Kelshi 1 and 2 locations than locations at Dapoli and Pangari. It might be due to regular and higher application of $CuSO_4$ and organic materials. As per the soil fertility norms for Alphonso mango given by Raghupathi and Bhargava (1997) [4], all the soil samples had 'optimum' class for available Cu with exception of few samples at Pangari location. The observed range for available copper was also reported by [8].

A rise in available zinc content of soil was observed after fertilizer application and its reducing trend was noticed from pre-flowering stage at all locations during the both years with exceptions of Kelshi 2, Dapoli and Pangari locations in first year

[Table-1]. This trend is also reported by [7]. The available Zn content was observed higher at Kelshi 1 and 2 locations than at Dapoli and Pangari locations. It might be attributed to application of $ZnSO_4$ through soil. The soil fertility norms of Raghupathi and Bhargava (1997) [4] for Alphonso mango suggested that most of the samples from both the Kelshi locations and Dapoli location had 'low to optimum' class for available zinc. In case of Pangari location, all the samples showed poor status (very low class) of available Zn content. Similar range was observed by Gaidhani (2008) [9] for lateritic soils of Konkan.

Micronutrient status of leaf

The data presented in [Table-2] showed that the total Fe content in leaves went up till the flowering stage and then went down at marble stage at all the locations and during both the years

Table- 2 *Location-wise total micronutrients contents in leaf (µg g^{-1}) at different stages of crop*

Nutrient	Stages	Range	Kelshi 1		Kelshi 2		Dapoli		Pangari	
			I	II	I	II	I	II	I	II
Fe	S I	Min.	37.59	54.33	35.44	45.34	30.25	35.69	25.48	21.90
		Max.	45.66	63.20	44.36	55.46	38.78	41.22	34.55	29.67
	SII	Min.	53.20	65.38	42.03	56.30	39.90	47.70	34.21	33.29
		Max.	61.34	71.25	48.70	64.55	45.17	55.41	40.50	40.74
	S III	Min.	68.69	74.21	37.60	69.62	46.55	53.40	25.46	35.46
		Max.	79.12	81.24	67.70	78.99	56.40	65.49	32.19	44.23
	SIV	Min.	64.21	65.86	48.69	52.18	35.25	33.60	22.35	28.79
		Max.	72.35	75.56	60.17	65.44	49.88	41.22	29.65	35.54
	SV	Min.	60.90	56.50	46.26	49.80	30.11	47.70	20.51	20.90
		Max.	70.87	63.98	58.18	62.13	45.64	55.41	25.45	29.70
Mn	S I	Min.	28.70	29.80	23.56	20.99	22.30	14.45	17.80	15.35
		Max.	34.55	37.65	30.54	27.56	28.70	22.30	23.45	19.07
	SII	Min.	35.46	42.11	25.48	30.22	26.89	23.34	24.14	20.29
		Max.	44.31	50.06	33.40	37.70	34.52	29.88	28.71	26.34
	S III	Min.	40.90	53.33	24.59	46.52	29.08	36.57	20.14	28.99
		Max.	48.68	60.70	36.55	54.91	36.59	42.21	27.81	34.53
	SIV	Min.	33.20	47.67	20.19	37.85	17.60	23.65	16.50	22.44
		Max.	45.35	56.69	30.09	45.90	29.06	34.56	24.92	28.07
	SV	Min.	31.12	35.40	21.46	30.43	15.44	20.09	17.10	16.80
		Max.	40.90	50.24	27.69	40.87	20.10	29.64	22.95	24.35
Cu	S I	Min.	36.77	34.99	25.74	21.13	26.50	20.54	11.21	9.77
		Max.	48.02	42.40	36.50	32.79	35.93	32.26	20.00	15.44
	SII	Min.	42.21	41.27	24.39	29.39	24.03	30.86	10.91	16.52
		Max.	54.30	49.06	33.83	40.00	34.55	40.03	18.59	22.19
	SIII	Min.	47.56	46.30	24.50	36.34	26.41	32.14	14.34	20.30
		Max.	55.20	55.75	39.11	46.99	34.69	42.60	21.05	25.96
	SIV	Min.	45.33	47.05	30.09	41.92	29.68	35.80	16.33	17.18
		Max.	59.80	58.00	45.59	50.89	39.00	46.63	23.28	31.91
	SV	Min.	44.03	34.62	34.30	31.34	24.33	19.57	10.95	16.64
		Max.	52.01	43.96	36.21	43.49	36.12	28.40	18.88	25.70
Zn	S I	Min.	25.14	26.57	21.23	19.67	22.38	19.14	16.75	9.80
		Max.	34.13	35.38	30.99	29.40	28.10	26.90	24.59	14.28
	SII	Min.	23.39	33.65	24.93	27.30	24.58	24.00	12.54	16.50
		Max.	40.82	39.07	35.46	34.00	36.56	34.55	20.30	24.83
	S III	Min.	31.87	35.88	25.02	30.85	25.53	22.64	16.78	18.67
		Max.	43.55	44.52	34.50	40.50	34.22	37.61	23.40	26.85
	S IV	Min.	37.60	37.47	28.90	34.02	26.00	31.80	16.59	21.00
		Max.	50.20	53.35	37.48	43.69	35.65	38.66	25.35	30.46
	S V	Min.	34.00	29.00	25.41	28.44	23.74	26.90	13.45	18.53
		Max.	43.21	39.46	33.85	35.35	30.28	32.00	20.04	23.11

with exception of Pangari location during first year [10] and [7] also observed a decrease in iron content in leaves of Alphonso mango during fruit developmental stages. Higher Fe content in leaves observed for both the Kelshi locations than Dapoli and Pangari locations may be due to higher application of it with organic matter. On the basis of the leaf nutrient norms given by [11], all the leaf samples at all locations were found to be 'deficient' in total iron content. Similar contents for

iron in leaves of mango were reported by [12].

Stage-wise fluctuations in content of leaf Mn [Table-2] showed that at all locations. It increased after fertilizer application till flowering stage and then decreased at marble stage in first as well as in second year with exception of Pangari location during first year. [13] and [7] also noticed similar type of variation in the content of Mn. As per the nutrient norms suggested by [11], all the samples were in 'optimum' status for total Mn content of leaf. The observed range of manganese content in leaf was also reported by [14] and [15]. From the location-wise study with respect to Mn content, it was observed that both the Kelshi locations had higher content of leaf Mn than Dapoli and Pangari locations which may be a result of higher application of Mn through soil and leaf.

In case of the total copper content in leaves [Table-2], it got raised continuously after fertilizer application up to flowering stage and then reduced at marble stage at all the locations during first as well as second year with exceptions of Kelshi 2, Dapoli and Pangari locations in first year. [16] for Tommy Atkins mango, [13] for Amrapali mango and [7] for Alphonso mango also observed an increasing trend of leaf Cu content during reproductive stage. The Cu content of mango leaves was higher for Kelshi 1 and Kelshi 2 locations as compared to Dapoli and Pangari locations. This may attributed to addition of $CuSO_4$ in soil and it's sprayingon leaves at Kelshi 1 and Kelshi 2 locations. All the leaf samples at all locations had 'optimum to excessive' copper content according to the ratings given by [11] for Alphonso mango of Ratnagiri district. Similar range for total Cu content was also reported by [17] for Alphonso mango orchards of Konkan region.

From, [Table-2], it was also seen that, during both the years after application of fertilizer the total Zn content in leaves had continuously risen till flowering stage and afterwards it had fallen at marble stage at all locations except Pangari in first year. A similar trend was noticed by [13] and [7]. Higher content of zinc was observed at Kelshi 1 and Kelshi 2 locations than Dapoli and Pangari locations which might be the result of its higher availability at these mango orchards due to application of $ZnSO_4$ through foliar sprays. In general, all the mango orchards had 'optimum to high' class of leaf Zn as per the ratings given by [11] for Alphonso mango of Ratnagiri district. The observed content of zinc in leaves of Alphonso mango from Konkan region was reported by [18] and [7].

Yield data

The fruit yield of each selected tree from all the orchards was recorded during both the years. Following is the average yield of the selected twelve trees.

Table-3 *Average yield (kg tree^{-1})*

Location	First year (2013-2014)	Second year (2014-2015)
Kelshi 1	156.23	112.50
Kelshi 2	332.65	200.14
Dapoli	43.73	56.90
Pangari	10.87	9.60

From the above table, it was observed that during both the years considerably higher yields were recorded at both the Kelshi locations than Dapoli and Pangari locations. The cause for this may be higher nutrient content in soil and leaf throughout the year at Kelshi orchards than Dapoli and Pangari orchards. The higher soil and leaf nutrient status might be attributed to regular, proper and more application of nutrients at various stages at these orchards than Dapoli and Pangari orchards.

Correlations between micronutrients and yield:

The correlations of micronutrient contents of soil and leaf with yield, irrespective of the locations and the stages are given in [Table-3].

As seen from [Table-3], the soil Fe had a positive and significant correlation in first (r = 0.326*) and in second (r = 0.290*) year and the leaf Fe showed a positive and significant relationship in first (r = 0.364**) as well as in second (r = 0.228*) year with yield. In case of manganese content, the content in soil had positive and significant correlation with yield in second year (r = 0.201*). The manganese content of leaf was positively and significantly correlated (r = 0.256**) in first year and (r = 0.414**) in second year with yield. During second year, a positive and significant correlation was observed between available Cu content of soil and yield (r = 0.145*) while during both the years, total Cu content in leaves had a positive and significant correlation with yield as (r = 0.344**) and(r = 0.448*), respectively. The zinc content of soil had a positive and significant relationship with yield (r = 0.123*) in first year and the total zinc content in leaf also had a positive and significant correlation during first (r = 0.189**) and second (r = 0.317**) year with yield. [19] observed that the Fe, Mn, Zn and Cu content of soil and leaf in mango were positively and significantly correlated with each other.

In general, positive and significant correlations of soil and leaf nutrient status with yield showed that the increase in the nutrient status of soil and leaf was related with increase in the yield. This indicates the relevance of nutrient content in soil and leaf or the effect of applied nutrients through soil and leaf in increasing the yield. Further, it was also noticed that the leaf nutrient content had better correlation with yield than soil nutrient status.

Conclusion

Higher application of iron and zinc to soil at Dapoli and Pangari locations was found essential for fulfilling the deficiencies. The poor status of iron (regardless of its sufficiency in soil) content of leaf at all the locations needs to be corrected through sufficient supply of these nutrients through foliar sprays during vegetative and reproductive stages. In case of leaf nutrients, existing adequate amounts of total manganese, copper and zinc at all the locations can be maintained by proper application of them through soil and leaf throughout the life cycle of the tree. To improve nutrient status of soil and leaf and to enhance the yield at Dapoli and Pangari locations, it is essential to supply higher quantities of micronutrients through soil and leaf. For enhancing the yield, it is necessary to maintain optimum nutrient contents in soil and leaf. From the aforesaid findings, it is affirmed that the appropriate nutrient management in case of mango is crucial for higher yields.

Conflict of Interest: None declared

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