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Leaf Nutrient Standards for Mango (*Mangifera indica* L.)

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Abstract

The present investigations on standardization of leaf nutrient norms in mango orchards cv Dashehari located in Himachal Pradesh were carried out during 2004 and 2005. The studies were undertaken with the objectives to find out the nutritional status of mango orchards and to establish nutrient standards for leaf based on orchard surveys. The survey was carried out on trees of 15 years age group. Four districts of Himachal Pradesh viz. Kangra, Una, Hamirpur and Bilaspur, being major mango growing districts were selected according to probability proportional to size of sampling scheme. Five representative orchards from each district were selected. Optimum sample size of 10 trees from each orchard based on average national productivity i.e.>90 kg/tree were selected to standardize the nutrient ranges. Nutrient content of leaf varied from 1.87—2.34% nitrogen (N), 0.117—0.157% phosphorus (P), 0.584—0.800% potassium (K), 1.80—2.46% calcium (Ca) and 0.79—1.37% magnesium (Mg). It is concluded that for sustainable production of Dashehari orchards under agro-climatic conditions of Himachal Pradesh, the nutrient content of leaf should be in the range of 1.87—2.33% N, 0.118—0.156% P, 0.585—0.796% K, 1.94—2.44% Ca and 0.81—1.36% Mg.

Key words : Leaf nutrient standards, Mango, Dashehari.

Mango (*Mangifera indica* L.) is one of the leading fruits of foothills of Himachal Pradesh, belongs to family Anacardiaceae. It occupies the total harvested area of 36,215 ha with production of 63,091 MT in Himachal Pradesh (1). Nutrient management is one of the important considerations for fruit production of perennial crops which are quite different from other seasonal crops in nutritional requirements due to their size, density, rate of growth, root pattern and phenomenon of fruit bud differentiation and its relationships with the yield during the following season/year and moreover, they continue growth at any place throughout their life span for longer period. So far, very little work has been reported on the nutrition of mango in India, particularly in Himachal Pradesh, and the nutrient standards of other countries and developed by the adjoining states are being followed for assessing the nutritional status of the trees. This may not be appropriate and the interpretation of results based on the nutrient standards from abroad may be misleading. It is therefore, imperative that the standards should be defined for the different agro-climatic zonrs where mango is commercially grown. Once leaf sampling and analytical methods have been standardized, the interpretation of results is carried out based on classical concepts such as concentration on dry matter basis, sufficiency ranges, standard and critical values, nutrient balance and nutrient ratios. Further, the relationship between leaf composition and the tree performance may be expressed as standard nutrient classes, which hold well in a location where they are developed. Nutrient standards based on orchard surveys have been established (2—4) and many more. It has been suggested that the nutrient standards of one region cannot be applied in other because of differences in the nutrient supply, sampling and other analytical techniques. The present studies, therefore, were undertaken with the objective to standardize the nutrient ranges in Dashehari mango, which is a main variety being grown in mid to low hill elevations of Himachal Pradesh.

Methods

The survey was carried out on full bearing healthy trees of mango cv Dashehari of 15 years age group during 2004 and 2005. Four districts of Himachal Pradesh were selected purposely viz. Bilaspur,

Table 1. Leaf composition of macronutrients (N, P, K) of Dashehari trees.

District	Orchard	N (%)			P (%)			K (%)		
		2004	2005	Pooled	2004	2005	Pooled	2004	2005	Pooled
	KGR-1	2.14	2.18	2.16	0.117	0.119	0.115	0.599	0.608	0.604
		(1.46)	(1.48)	(1.47)	(0.325)	(0.339)	(0.332)	(0.774)	(0.780)	(0.777)
	KGR-2	2.29	2.32	2.31	0.120	0.124	0.122	0.622	0.626	0.624
		(1.51)	(1.52)	(1.52)	(0.343)	(0.349)	(0.346)	(0.789)	(0.791)	(0.790)
Kangra	KGR-3	2.19	2.22	2.20	0.124	0.129	0.126	0.591	0.600	0.596
		(1.48)	(1.49)	(1.48)	(0.351)	(0.358)	(0.355)	(0.769)	(0.775)	(0.772)
	KGR-4	2.31	2.34	2.33	0.124	0.126	0.125	0.620	0.624	0.622
		(1.52)	(1.53)	(1.53)	(0.353)	(0.355)	(0.354)	(0.788)	(0.790)	(0.789)
	KGR-5	2.16	2.19	2.17	0.148	0.155	0.151	0.791	0.800	0.795
		(1.47)	(1.49)	(1.47)	(0.384)	(0.393)	(0.389)	(0.889)	(0.894)	(0.892)
	Average	2.22	2.25	2.23	0.125	0.130	0.128	0.645	0.652	0.648
		(1.49)	(1.50)	(1.49)	(0.351)	(0.359)	(0.355)	(0.802)	(0.806)	(0.804)
	UNA-1	2.07	2.10	2.09	0.140	0.142	0.141	0.682	0.685	0.683
		(1.44)	(1.45)	(1.44)	(0.374)	(0.378)	(0.376)	(0.826)	(0.827)	(0.827)
	UNA-2	2.07	2.10	2.09	0.153	0.157	0.155	0.689	0.694	0.692
		(1.44)	(1.45)	(1.44)	(0.391)	(0.397)	(0.394)	(0.830)	(0.833)	(0.832)
Una	UNA-3	2.20	2.22	2.21	0.136	0.141	0.139	0.642	0.649	0.645
		(1.48)	(1.49)	(1.49)	(0.370)	(0.376)	(0.373)	(0.801)	(0.806)	(0.803)
	UNA-4	1.92	1.95	1.94	0.127	0.133	0.130	0.663	0.670	0.666
		(1.39)	(1.40)	(1.39)	(0.356)	(0.364)	(0.360)	(0.814)	(0.818)	(0.816)
	UNA-5	2.12	2.16	2.14	0.122	0.126	0.124	0.681	0.688	0.685
		(1.46)	(1.47)	(1.46)	(0.350)	(0.355)	(0.352)	(0.825)	(0.829)	(0.827)
	Average	2.08	2.11	2.09	0.136	0.140	0.138	0.671	0.677	0.674
		(1.45)	(1.46)	(1.46)	(0.368)	(0.374)	(0.371)	(0.819)	(0.823)	(0.821)
	HMR-1	2.12	2.13	2.12	0.156	0.157	0.157	0.669	0.673	0.671
		(1.46)	(1.46)	(1.46)	(0.395)	(0.397)	(0.396)	(0.818)	(0.820)	(0.819)
	HMR-2	2.03	2.04	2.04	0.148	0.150	0.149	0.683	0.685	0.684
		(1.42)	(1.43)	(1.43)	(0.385)	(0.388)	(0.386)	(0.826)	(0.828)	(0.827)
Hamirpur	HMR-3	2.21	2.23	2.22	0.131	0.133	0.132	0.645	0.649	0.647
		(1.49)	(1.49)	(1.49)	(0.362)	(0.365)	(0.363)	(0.803)	(0.806)	(0.805)
	HMR-4	2.03	2.06	2.05	0.124	0.128	0.126	0.660	0.663	0.661
		(1.43)	(1.44)	(1.43)	(0.352)	(0.357)	(0.355)	(0.812)	(0.814)	(0.813)
	HMR-5	2.14	2.17	2.16	0.130	0.134	0.132	0.678	0.682	0.680
		(1.46)	(1.48)	(1.47)	(0.360)	(0.366)	(0.363)	(0.823)	(0.826)	(0.825)
	Average	2.11	2.12	2.12	0.137	0.141	0.139	0.667	0.670	0.669
		(1.44)	(1.45)	(1.45)	(0.371)	(0.374)	(0.373)	(0.817)	(0.819)	(0.818)
	BLP-1	2.20	2.22	2.21	0.129	0.133	0.131	0.680	0.688	0.686
		(1.48)	(1.49)	(1.47)	(0.360)	(0.365)	(0.362)	(0.827)	(0.829)	(0.828)
	BLP-2	2.08	2.10	2.09	0.140	0.143	0.141	0.689	0.691	0.690
		(1.44)	(1.45)	(1.45)	(0.374)	(0.378)	(0.376)	(0.830)	(0.831)	(0.831)
Bilaspur	BLP-3	1.96	1.98	1.97	0.152	0.154	0.153	0.703	0.707	0.705
		(1.40)	(1.41)	(1.40)	(0.390)	(0.392)	(0.391)	(0.838)	(0.841)	(0.839)
	BLP-4	1.87	1.88	1.88	0.149	0.152	0.150	0.682	0.686	0.684
		(1.37)	(1.37)	(1.37)	(0.386)	(0.390)	(0.388)	(0.826)	(0.828)	(0.827)
	BLP-5	2.00	2.10	2.05	0.140	0.142	0.141	0.584	0.586	0.585
		(1.42)	(1.45)	(1.43)	(0.374)	(0.377)	(0.376)	(0.764)	(0.765)	(0.765)
	Average	2.02	0.06	0.04	0.142	0.145	0.143	0.668	0.671	0.670
		(1.42)	(1.43)	(1.43)	(0.377)	(0.380)	(0.378)	(0.817)	(0.819)	(0.818)
CD 0.05										
District		0.01	0.01	0.01	0.009	0.008	0.008	0.002	0.002	0.002
Orchard		0.01	0.01	0.01	0.010	0.008	0.009	0.002	0.002	0.002
Orchard × District		0.02	0.02	0.02	0.020	0.017	0.018	0.004	0.004	0.004

Table 1. (Continued). Leaf composition of macronutrients (Ca, Mg) of Dasheari trees.

District	Orchard	Ca (%) 2004	Ca (%) 2005	Ca (%) Pooled	Mg (%) 2004	Mg (%) 2005	Mg (%) Pooled
	KGR-1	2.25	2.34	2.29	0.90	0.99	0.94
		(1.50)	(1.53)	(1.52)	(0.95)	(1.00)	(0.97)
	KGR-2	2.33	2.37	2.35	1.03	1.06	0.04
		(1.53)	(1.54)	(1.53)	(1.01)	(1.03)	(1.02)
Kangra	KGR-3	2.14	2.16	2.15	0.91	0.95	0.93
		(1.46)	(1.47)	(1.47)	(0.95)	(0.97)	(0.96)
	KGR-4	2.18	2.24	2.21	1.01	1.05	0.03
		(1.48)	(1.50)	(1.49)	(1.00)	(1.03)	(1.01)
	KGR-5	2.42	2.46	2.44	0.97	0.83	0.81
		(1.56)	(1.57)	(1.56)	(0.89)	(0.91)	(0.90)
	Average	2.27	2.31	2.29	0.93	0.98	0.95
		(1.51)	(1.52)	(1.51)	(0.96)	(0.97)	(0.97)
	UNA-1	2.00	2.03	2.01	1.16	1.21	1.18
		(1.41)	(1.42)	(1.42)	(1.07)	(1.10)	(1.09)
	UNA-2	2.08	2.13	2.10	1.22	1.28	1.25
		(1.44)	(1.46)	(1.45)	(1.11)	(1.13)	(1.12)
Una	UNA-3	2.02	2.06	2.04	1.08	1.17	1.12
		(1.42)	(1.44)	(1.43)	(1.04)	(1.08)	(1.06)
	UNA-4	2.11	2.16	2.13	1.20	1.25	1.22
		(1.45)	(1.47)	(1.46)	(1.10)	(1.12)	(1.11)
	UNA-5	1.93	1.98	1.95	1.20	1.26	1.23
		(1.39)	(1.41)	(1.40)	(1.09)	(1.12)	(1.11)
	Average	2.03	2.07	2.05	1.17	1.23	1.20
		(1.42)	(1.44)	(1.43)	(1.08)	(1.11)	(1.10)
	HMR-1	1.93	1.95	1.94	1.19	1.22	1.20
		(1.39)	(1.40)	(1.39)	(1.09)	(1.10)	(1.10)
	HMR-2	2.02	2.06	2.04	1.21	1.23	1.22
		(1.42)	(1.44)	(1.43)	(1.10)	(1.11)	(1.11)
Hamirpur	HMR-3	1.93	1.96	1.94	1.06	1.08	1.07
		(1.39)	(1.40)	(1.39)	(1.03)	(1.04)	(1.03)
	HMR-4	2.05	2.09	2.07	1.12	1.14	1.13
		(1.43)	(1.45)	(1.44)	(1.06)	(1.07)	(1.06)
	HMR-5	1.80	1.85	1.83	1.45	1.50	1.48
		(1.34)	(1.36)	(1.35)	(1.21)	(1.22)	(1.22)
	Average	1.95	1.98	1.96	1.21	1.23	1.22
		(1.39)	(1.41)	(1.40)	(1.10)	(1.11)	(1.10)
	BLP-1	2.13	2.17	2.15	1.34	1.37	1.35
		(1.46)	(1.47)	(1.47)	(1.16)	(1.17)	(1.16)
	BLP-2	2.19	2.20	2.19	1.29	1.32	1.30
		(1.48)	(1.48)	(1.48)	(1.13)	(1.15)	(1.14)
Bilaspur	BLP-3	2.15	2.17	2.16	1.18	1.21	1.19
		(1.47)	(1.47)	(1.47)	(1.09)	(1.10)	(1.09)
	BLP-4	2.18	2.19	2.19	1.27	1.29	1.28
		(1.48)	(1.48)	(1.48)	(1.13)	(1.14)	(1.13)
	BLP-5	2.07	2.09	2.08	1.19	1.22	1.21
		(1.44)	(1.45)	(1.44)	(1.09)	(1.10)	(1.10)
	Average	2.14	2.17	2.15	1.24	1.28	1.27
		(1.46)	(1.47)	(1.47)	(1.12)	(1.13)	(1.13)
CD 0.05 District		0.01	0.01	0.01	0.01	0.01	0.01
Orchard		0.01	0.01	0.01	0.01	0.01	0.01
Orchard × District		0.02	0.01	0.01	0.02	0.02	0.02

Hamirpur, Una and Kangra, being major mango growing districts. Representative sample of five orchards from each district were selected using probability proportional to size sampling scheme, taking number of

trees per orchard as an auxiliary variable. An optimum sample size of 10 trees from each orchard based on average national productivity level i.e.>90 kg/tree, were selected randomly on the basis of apparent performance and the past history of the trees. The sampling of leaves and their preparation for chemical analysis was in accordance with Chapman (5). Each foliage sample was made up of 50 leaves taken during April from middle of the shoot (non-fruiting and non-flushing twigs) from December flush (6) in both the years.

The leaves were analyzed for primary (N, P, K) and secondary (Ca, Mg) nutrients. The digestion of leaf samples (1 g) for the estimation of total nitrogen was carried out in concentrated H_2SO_4 in the presence of a digestion mixture : K_2SO_4 (400 parts), $CuSO_4$ (20 parts), mercuric oxide (3 parts), and Selenium powder (1 part) and total N content was estimated by Autoanalyzer Kjel Tech Model Foss Tecator 2300. For the estimation of P, K, Ca and Mg, the leaf samples (0.5 g) were digested in diacid mixture prepared by mixing HNO_3 and $HClO_4$ in the ratio of 4:1. Total phosphorus content was determined by vanadomolybedate yellow color method (7), K by Flame photometer, and Ca and Mg by Perkins Elmen atomic absorption spectrophotometer.

Soil samples were also collected from the drip line of each tree from 0—30 and 30—60 cm depths simultaneously along with leaf samples. The samples thus collected were composited separately. Sample preparation and chemical analysis was done using standard methods of estimation.

Statistical analysis was worked out using the data obtained from orchard surveys through randomized block design (factorial) following the procedure given by Panse and Sukhatme (8). The different orchards (district-wise) were taken as treatments and trees as replications.

Results and Discussion

The nutritional status of different mango orchards with relation to macronutient contents of leaf and chemical characteristics of soil are presented in Tables 1 and 2, respectively.

Nitrogen

The pooled data indicates that the average leaf nitrogen content was highest in Kangra district (2.23%), followed by Hamirpur (2.12%), Una (2.09%) and Bilaspur (2.04%) districts (Table 1). The leaf nitrogen values (1.87—2.34%) were found in the optimum range according to the standards prepared by Samra et al. (2) and Chaudhary and Nauriyal (9), who have 0.95 to 1.45% and 1.26 to 1.88%, respectively as the optimum leaf N standards for Dashehari trees. All the orchards were also in satisfactory range when compared with standard values described by Padmaja et al. (10) and Pimplaskar and Bhargava (11). The optimum leaf N status of these trees also represented the medium available N status of the soils (177.60 to 213.60 mg/kg at 0—30 cm and 135.40 to 149.30 mg/kg at 30—60 cm depth), which showed that the productivity of the trees was influenced by the N availability of the soils and its consequent uptake by the plants. Rao and Mukherjee (12) gave a clear positive and significant relationship between leaf N and available N content of soils of Dashehari trees. The average leaf N content exhibited by different district was also in the optimum range, which was represented by medium available N content of the soils. Although, the districts significantly differed from one another, yet the average leaf N status was in the satisfactory range. Among the districts surveyed, Bilaspur district exhibited the lowest average leaf N and available N status of the soils but the average soil organic carbon content of soil was 2.03% and 1.98% at 0—30 and 30—60 cm depths, respectively, was higher than 1.88 to 2.02, and 1.74 to 1.91 at 0—30 and 30—60 cm depths, respectively, notwithstanding the differences in the satisfactory status of the trees. This shows that nutrient dynamics was not as efficient in the district than in the soils of other districts. The low availability of N in the district might be due to show rate of mineralization resulted from comparatively low temperatures.

Phosphorus

The pooled data with respect to phosphorus content of leaves reveal that the leaf P content exhibited a range of 0.115 to 0.157%. The highest average leaf P status was observed in Bilaspur district (0.143%), followed by Hamirpur (0.139%), Una (0.138%) and Kangra (0.128%) districts. The average leaf P content of Bilaspur district was statistically at par with

Table 2. Soil chemical characteristics of Dashehari trees.

	Kangra					
	2004		2005		Pooled	
	0—30 cm	30—60 cm	0—30 cm	30—60 cm	0—30 cm	30—60 cm
pH	6.95	6.85	6.92	6.86	6.94	6.86
EC (dS/m)	0.29	0.27	0.30	0.26	0.29	0.26
OC (%)	1.97	1.89	1.85	1.65	1.91	1.77
N (mg/kg)	209.60	149.30	213.60	147.40	211.60	148.40
P (mg/kg)	7.64	5.94	7.47	6.21	7.56	6.08
K (mg/kg)	135.00	125.60	130.40	121.20	133.20	123.40
Ca (mg/kg)	2885.00	2300.40	2600.00	2306.00	2742.50	2303.20
Mg (mg/kg)	890.30	690.30	833.60	657.50	861.90	673.90

Table 2. Continued.

	Una					
	2004		2005		Pooled	
	0—30 cm	30—60 cm	0—30 cm	30—60 cm	0—30 cm	30—60 cm
pH	7.38	7.29	7.36	7.37	7.37	7.33
EC (dS/m)	0.22	0.24	0.25	0.21	0.24	0.23
OC (%)	2.03	1.92	2.00	1.00	2.02	1.91
N (mg/kg)	198.60	140.30	189.59	139.60	194.10	139.95
P (mg.kg)	5.85	4.39	5.91	4.44	5.88	4.42
K (mg/kg)	136.20	123.40	130.40	125.40	133.30	124.40
Ca (mg/kg)	1965.70	1906.30	1810.40	1677.30	1888.10	1791.80
Mg (mg/kg)	990.50	750.40	877.60	790.50	934.10	770.45

Table 2. Continued.

	Hamirpur					
	2004		2005		Pooled	
	0—30 cm	30—60 cm	0—30 cm	30—60 cm	0—30 cm	30—60 cm
pH	7.00	6.97	7.31	7.27	7.16	7.12
EC (dS/m)	0.20	0.22	0.18	0.18	0.19	0.19
OC (%)	1.86	1.76	1.89	1.71	1.88	1.74
N (mg/kg)	184.60	136.50	191.50	140.90	188.10	138.70
P (mg/kg)	6.57	5.03	6.60	5.06	6.59	5.05
K (mg/kg)	141.00	127.90	143.70	129.40	142.40	128.65
Ca (mg/kg)	1890.40	1799.30	1828.50	1780.00	1859.50	1789.65
Mg (mg/kg)	1010.30	803.40	1032.00	806.10	1021.20	803.30

Table 2. Continued.

	Bilaspur					
	2004		2005		Pooled	
	0—30 cm	30—60 cm	0—30 cm	30—60 cm	0—30 cm	30—60 cm
pH	7.21	7.05	7.27	7.20	7.24	7.13
EC (dS/m)	0.30	0.29	0.34	0.31	0.32	0.30
OC (%)	2.03	1.97	2.00	1.98	2.03	1.98
N (mg/kg)	177.60	135.40	189.30	139.50	183.50	137.50
P (mg/kg)	8.34	7.24	7.96	7.77	8.15	7.51
K (mg/kg)	147.10	133.60	144.40	127.40	145.80	130.50
Ca (mg/kg)	2100.70	1910.30	2246.40	1860.20	2173.60	1885.30
Mg (mg/kg)	1245.60	910.50	1210.30	845.60	1227.90	878.10

Hamirpur and Una districts (Table 1). The leaf phosphorus status (0.117—0.157%) was in the satisfactory range when compared with the standard values given by Ahlawat et al. (13) but this was in low range when compared with the values given by Bhargava (14) and Poovarodom et al. (15). Kenworthy and Martin (16) stated that mango leaves should contain 0.055% P for the optimum growth and fruiting of the trees, whereas Kumar and Nauriyal (17) standardized an optimum leaf P of 0.150% in mango fed with complete nutrient solution. Pimplaskar and Bhargava (11), however, gave leaf P content in Rajapuri mango as 0.112 to 0.135% in the high range. The average leaf P status of different districts, however, was optimum. The trees also represented medium average available soil P status (5.85 to 8.34 mg/kg at 0—30 cm and 4.39 to 7.24 mg/kg at 30—60 cm depths), and as such might have been responsible for optimum P status of the trees. All the districts represented average optimum leaf P status. Among them, Una district exhibited the lowest average available P which might have been influenced by pH of the soils which was 7.37 at 0—30 cm and 7.33 at 30—60 cm depth as compared with average of 7.11 at 0—30 and 7.03 at 30—60 cm depth in other districts.

Potassium

It is evident that the highest average leaf potassium content was observed in Una district (0.674%), followed by Bilaspur (0.670%), Hamirpur (0.669%) and Kangra (0.648%) districts. The average leaf K content recorded in Una district was significanty higher than all other districts. The leaf K content (0.584—0.800%) was found to be in the optimum range when compared with Bhargava (14) who gave 0.520 to 1.100% leaf K content as the satisfactory range for normal growth and fruiting in Totapuri mango. The available K status of the orchards was in the medium range. The average available K status in different districts was also in the optimum range and hence, its consequent uptake by the plants.

Calcium

The highest average leaf Ca content was exhibited by Kangra district (2.29%), followed by Bilaspur (2.15%), Una (2.05%) and Hamirpur (1.96%) districts. The concentration of leaf K content (1.80—2.46%) was in the optimum range according to the Samra et al. (2) and Bhargava (14) who gave 1.74 to 2.80% and 1.97 to 3.20% leaf Ca content as optimum in mango, respectively. It has been observed that with concomitant high Ca content in soils, the plants often acquire high Ca content (18). The trees also represented the medium average available P status and might have been responsible for sufficient Ca status of the trees.

Magnesium

The pooled data indicate that Bilaspur district exhibited the highest average Mg content (1.27%) followed by Hamirpur (1.22%), Una (1.20%) and Kangra (0.95%) districts. The average leaf Mg content exhibited by Hamirpur district was statistically at par with Una district. The leaf Mg status (0.79—1.37%) was in the optimum range when compared with standard value given by Bopaiah and Srivastava (19) who reported optimum leaf Mg content in fruiting (2.59%) and non-fruiting (2.58) terminals of Dashehari trees. Although there were significant differences in the leaf Mg status in different districts yet the values were found in the optimum range. The available Mg content was in the high range and might have been responsible for optimum Mg content in the leaves. Among the different districts, Bilaspur district exhibited significantly higher average leaf Mg content that might be due to significantly higher average leaf P content observed in this district.

Conclusion

Thus it can be concluded that for sustainable production of mango cultivar Dashehari under agro-climatic zone conditions of Himachal Pradesh, the macro-nutrient content of leaves should be in the ranges of 1.87—2.33% N, 0.118—0.156%P, 0.585—0.796% K, 1.94—2.44% Ca and 0.81—1.36% Mg.

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