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Full Length Research Paper

Fertility status of guava orchards in Kohat District of Pakistan

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A study was conducted to assess the fertility status of the soils of 44 guava orchards in Kohat District of Pakistan. Results showed that the soils generally contained large proportion of silt followed by sand with very small proportion of clay. Average organic matter content in the surface soil was 2.24% and in subsoil 1.42%. Soil pH ranged between 7.8 and 8.8. Soils at surface were non saline except one sample with EC ranging from 0.49 to 1.8 dS m^{-1} and in subsoil from 0.55 to 7.26 dS m^{-1}. Soils were strongly calcareous with lime content ranging from 15 to 25%. Extractable P ranged from 1 to 22 mg kg^{-1} in both depths. Available K was between 103 and 393 mg kg^{-1}, Nine, 16 and 43% of the orchards were low, 20, 18 and 48% marginal and 71, 66 and 9% were adequate in Zn, Fe and B in the surface soil while 7, 14 and 41% were low, 48, 27 and 52% marginal and 45, 59 and 7% of the orchards were adequate in Zn, Fe and B in the subsoil, respectively. Copper and Mn were adequate in all the orchards. Leaf P was low in 86% of the orchards. Potassium was marginal in 16% and high in 84%. Eleven percent of the orchards were low in Zn, 16% in Cu, 50% in Fe, 16% in Mn and 9% in B. Orchards found deficiency in the nutrients should be fertilized in order to supply the needed nutrients.

Key words: Guava, soil analysis, micro nutrients, soil fertility, Kohat.

INTRODUCTION

Guava (*Psidium guajava* L. Family Myrtaceae) has attained commercial importance in the tropics and subtropics because of its wide adaptability to varied soil and climatic conditions and as a prolific bearer. Guava is believed to originate in tropical America. At present, it is mainly produced in South Asian countries, the Hawaiian Island, Cuba, Brazil, Pakistan and India. Guava is the fourth most important fruit in Pakistan and was grown over an area of 62.5 thousand hectares with production of 555.3 thousand tons in the year of 2006 to 2007 (MINFAL, 2006-07). In North West Frontier Provinces (NWFP) of Pakistan, the area under guava orchards was 3.6 thousand hectares producing 43.0 thousand tons guava (MINFAL, 2006-07). The major guava growing areas include Shariqpur, Kasur, Lahore, Sheikhupora, Shangla Hills, Gujranwala in the Punjab; Kohat, Haripur and Bannu in the NWFP and Larkana and Hyderabad in Sindh.

Guava is frost sensitive, and tropical/subtropical climates with a distinct winter are preferred. The optimum summer temperature for growth is 23 to 28°C. It can be grown in a variety of soils ranging from heavy clays to sands with pH values varying from acidic to alkaline (Qureshi and Barrett, 1998). The tree grows best with an annual rainfall below 100 cm in June to September. It can thrive on soil from alluvial to lateritic but is sensitive to water logging. Suitable soils should be deep, friable and well drained. Guava cultivation should not be extended in saline or alkaline soils.

It had been established that plant removes a substantial amount of nutrients particularly nitrogen, phosphorus and potash from the soil. Therefore, soil fertility requirements of a crop need to be determined and maintained for the crop to be productive. In guava, fruits are borne on current season's growth. Balanced supply

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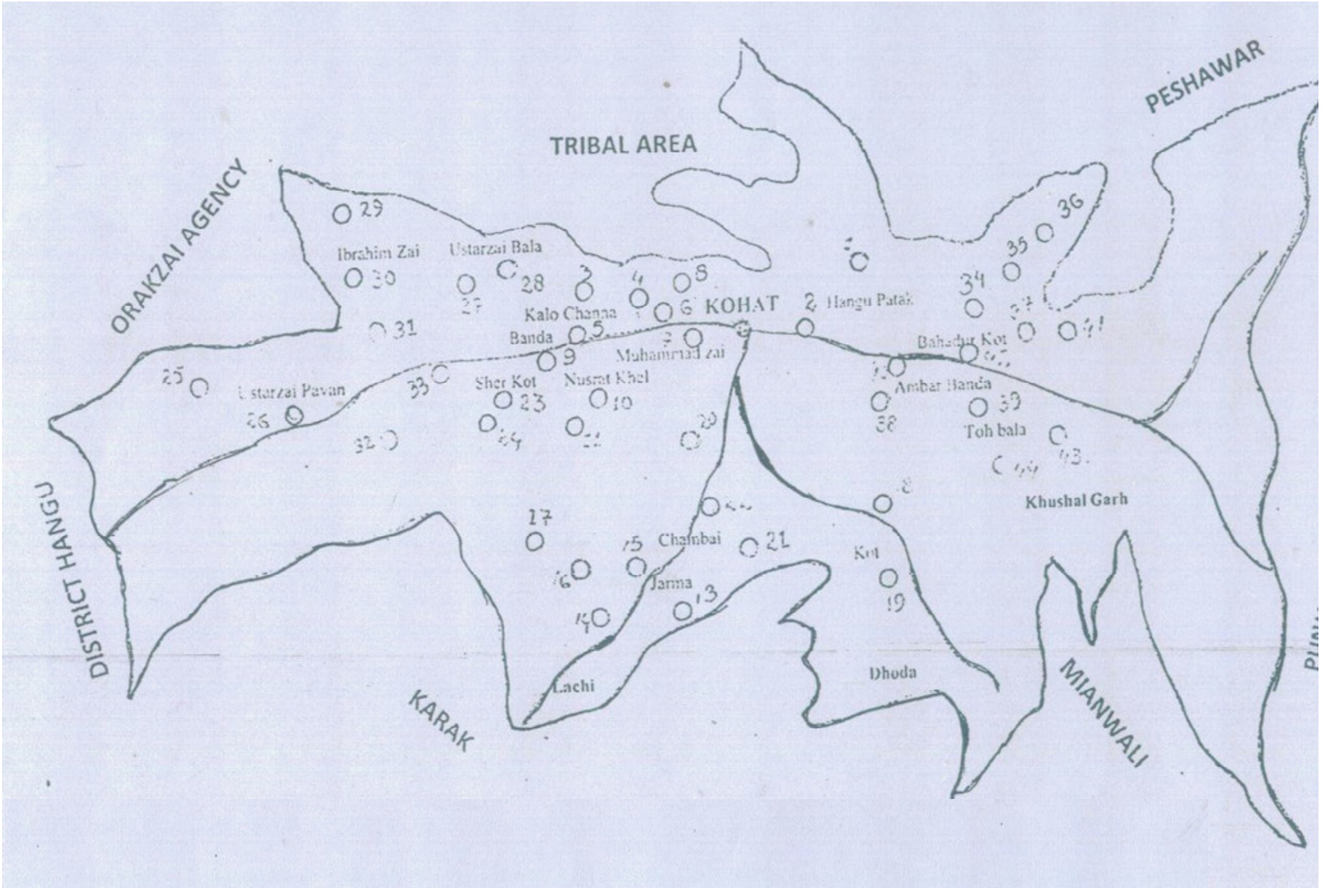

Figure 1. Map of Kohat District showing different sampling sites of experiment.

of NPK gives increased yield with quality fruit. In tropical and subtropical regions, poor nutrition is likely to be one of the major factors contributing to declining yield and quality. Locally, many trees in guava orchards appear unhealthy, and premature tree mortality is a widespread problem. Therefore precise knowledge about the nutrient status of guava trees is of prime importance for improving tree health, fruit yield and quality. Leaf analysis is a powerful tool in mineral nutrition research with fruit trees, not only to determine response to various nutrients but also as a diagnostic technique in assessing deficiency symptoms and making fertilizer recommendations (Natale et al., 2002). Soil fertility is declining day by day due to intensive cropping in order to fulfill the needs of rapidly growing population. To maintain the optimum fertility status of soil, application of different fertilizers is recommended by the agricultural scientists. The types and amounts of fertilizers to be applied depend on the crop to be grown and nutrient supplying power of the soil.

Soil testing and plant analysis serve as diagnostic tools, in addition to visual symptoms, for assessing any nutrient disorder. Periodic soil testing is the only way to understand the current fertility status of soil and maintain it in the future. Plant tissue analysis can also be used to verify soil fertility status, particularly for nutrients not easily measured in routine soil tests (nitrogen, sulfur, boron). However, the results of leaf analysis have proved difficult to interpret because the minimum or critical concentration of a specific nutrient in the shoots for optimum growth may change with the age of the plant and concentrations of other nutrients (Walworth and Sumner, 1987). Presently, such information is not available in the study area and this explains why this study was conducted to assess the fertility status of guava orchards in the Kohat District of Pakistan.

MATERIALS AND MEHTODS

Forty four guava orchard sites were surveyed in the Kohat District Pakistan through soil tests and tissue analysis. During the survey, history of each orchard was recorded (Figure 1).

Soil and plant sampling

Soil samples were collected from each selected orchard at 0 to 25 and 25 to 45 cm depths using the outer periphery of tree canopy or at the centre of four trees with the help of soil auger in April 2008. After air drying, soil samples were ground and passed through 2

Table 1. Particle size analysis of the soils of guava orchards in Kohat district.

Texture class	No. of orchards
Silt loam	68
Loam	11
Sandy loam	2
Silt	3
Clay	2
Silty clay loam	1
Clay loam	1

mm sieve for laboratory analyses. At the time of soil sampling, a total of 20 to 25 leaves corresponding to 3rd pair of recently matured leaves were handpicked from all the sides of randomly selected trees of the same orchard at nearly mid-height (about 2-m from the orchard floor) of the plant (Tandon, 1993). These were kept in labeled paper bags, and transported to the laboratory for further processing.

Soil and leaf analysis

Soil samples were analyzed for extractable macro (P and K) and micronutrients (Zn, Cu, Fe, Mn, and B), organic matter, pH, EC and soil texture. The leaf samples were analyzed for total macro (P and K) and micro (Zn, Cu, Fe, Mn, and B) nutrients. The concentration of extractable micronutrients (Zn, Cu, Fe and Mn) in soil was determined by the ammonium bicarbonate diethylene triamine pentaacetic acid (AB-DTPA) solution as described by Soltanpour (1985) using atomic absorption spectrophotometer (Perkin Elmer Analyst-200, USA). The concentration of extractable B in soil was determined using dilute HCl method (Ryan et al., 2001) and measured by the Curcumine method (Page et al., 1982) at 420 nm on spectrophotometer (Lambda-35). The extractable P and K in soil were also measured in the AB-DTPA extract (Soltanpour, 1985). Potash was read on flame photometer (Model PFP-7 Jenway, U.K) and P on spectrophotometer (Lambda-35) at 880 nm.

Soil pH and electrical conductivity (EC) were determined in soil water (1: 5) suspension. Using pH meter (Ino Lab pH Level I) and EC meter (DDC-308A), respectively. Organic matter was determined by Nelson and Sommers (1982) method while soil lime content was determined by Page et al. (1982) procedure and texture by Bouyoucos (1962) hydrometer method.

The concentration of micronutrients (Zn, Cu, Fe and Mn) in leaf samples was determined using the wet digestion procedure (Rashid, 1986). Boron concentration in leaf samples was determined using the wet digestion procedure (Rashid, 1986) as described by Ryan et al. (2001) and was determined calorimetrically using UV-Visible spectrophotometer after color development with curcumine oxalic acid (Page et al., 1982).

Descriptive statistics were used for calculation of means, standard deviations and coefficient of variations (Bhatti, 2006). Correlation studies were also performed using Steel and Torrie (1980) method.

RESULTS AND DISSCUSSION

Physical properties

Soil texture

The presented results of particle soil analysis of guava orchards (Table 1) showed that the soils generally contained large proportion of silt followed by sand and very small proportion of clay. Majority of soils were silt loam (77%) while the remaining soils were loam (13%), sandy loam (2%), silty clay loam (1%), silt (4%), clay (2%) and clayey loam (1%) in texture. These results suggested that the soils under guava orchards of Kohat District were generally medium textured which is considered optimum for orchards.

Chemical properties

Soil organic matter

The surface soil (0 to 25 cm) generally contained more organic matter than the soil at lower depth. In the surface soil, the minimum of organic matter 10.3 g kg^{-1} and maximum 47 g kg^{-1} with a mean value of 2.24 ± 0.64 g kg^{-1} were recorded (Table 2). In subsurface soil, it ranged from 6.2 to 28 g kg^{-1} with mean of 14.2 ± 4.4 g kg^{-1}. The organic matter content of soil at 0 to 25 cm depth was medium in two orchards and adequate in 42 orchards, none of the orchards was deficient in organic matter in the surface soil. At 25 to 45 cm depth, organic matter was low in 1 orchard, medium in 22 and adequate in 21 orchards. Comparing these results with the critical values of soil organic matter reported by Bhatti (1997), our data showed that in the surface soil, none of the orchards was low in organic matter but in subsurface it was low in only one orchard 2% (Table 3). Similarly, 5% of orchards were marginal in organic matter in the surface and 50% in the subsurface soil. Ninety five percent of the orchards were adequate in organic matter in the surface and 48% in the subsurface. Adequate organic matter content of the soils may be attributed to intense leaf fall on orchard floor.

Soil pH, EC and lime

Soil pH of most of the guava orchards was bet-ween 7.8 and 8.8 suggesting that the soils were generally alkaline in reaction. In surface soils, 98% fell in the pH range of below 8.5 and 2% was greater than 8.5. In subsurface

Table 2. Soil pH, EC, organic matter and lime of guava orchards in Kohat District.

Soil depth (cm)	pH				EC (dS m^{-1})			
	Mean	SD	Min	Max	Mean	SD	Min	Max
0-25	8.32	0.15	8.1	8.6	0.91	0.26	0.49	1.8
25-45	8.38	0.18	7.8	8.8	1.17	1.04	0.55	7.26
	Organic matter (g kg^{-1})				Lime (g kg^{-1})			
0-25	22.4	6.4	10.3	47.0	222.9	18.7	190	250
25-45	14.2	4.4	6.2	28.0	222.5	23.2	150	250

Table 3. Soils of guava orchards classified as saline/non-saline and acidic/alkaline.

Soil depth (cm)	pH (8-8.5)		pH (>8.5)		EC(<4.0 dS/m)		EC(>4.0 dS/m)			
	No. *	Percent	No.	Percent	No.	Percent	No.		Percent	
0-25	43	98	1	2	44	100	0		0	
25-45	37	84	7	16	43	98	1		2	
	Organic matter (g kg^{-1})						Lime (g kg^{-1})			
	Low		Medium		Adequate		Calcareous		Strongly calcareous	
	No.*	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
0-25	0	0	2	5	42	95	0	0	44	100
25-45	1	2	22	50	21	48	0	0	44	100

No., number of orchards; *out of 44 orchards.

soil, 84% fell below 8.5 and 16% greater than 8.5. These findings are in conformity with those of Haq et al. (1986). The results showed that soils at surface were non saline with EC ranging from 0.49 to 1.8 dS m^{-1} and mean of 0.91 dS m^{-1} in the subsurface, only one soil sample was saline and remaining soils were non saline having EC range of 0.55 to 7.26 dS m^{-1} and mean of 1.17 dS m^{-1}. Similar results were also reported by Haq et al. (1986). Guava plants are moderately tolerant to saline conditions and therefore most of the orchards have been planted on normal soils devoid of salt injury.

The results further demonstrated that lime in both surface and subsurface soils range from 19 to 25 and 15 to 25%, respectively were high which showed that the soils under guava orchards were strongly calcareous in nature. High lime content in the study area may be due to the soil parent material usually existing in the arid and semiarid regions.

Soil extractable P and K

The AB-DTPA extractable P in the soils is presented in Tables 4 to 5. Extractable P content varied with depth and from orchard to orchard location. The concentration of P in surface soils ranged from 1 to 21 µg g^{-1} soils with the mean

Table 4. Ammonium bicarbonate-DTPA extractable soil P and K (mg kg^{-1}).

Nutrient	Soil depth (cm)	Average	SD	Minimum	Maximum
P	0-25	6.05	3.89	1	21
	25-45	3.43	3.39	1	22
‘K	0-25	217.95	59.72	103	366
	25-45	182.70	66.53	103	393

Table 5. Soils of orchards classified as low, medium or adequate in AB-DTPA extractable P and K.

Nutrient	Soil depth (cm)	Low		Medium		Adequate	
		No.* of orchards	Percent	No. of orchards	Percent	No. of orchards	Percent
P	0-25	8	18	26	59	10	23
	25-45	33	75	9	20	2	5
K	0-25	0	0	2	5	42	95
	25-45	0	0	8	18	36	82

* Out of 44 orchards, AB-DTPA: Ammonium bicarbonate diethylene triamine pentaacetic acid.

value of 6.05 ± 3.89. In subsurface soils, it ranged from 1 to 22 µg g^{-1} soil with the mean value of 3.43 ± 3.39. The average P concentration was generally higher in the surface soils and decreased gradually with increasing soil depth. Comparing with the critical values of P in soils reported by Soltanpour (1985), our data showed that extractable soil P was deficient in both surface and subsurface soils of many of the orchards. It was evident that the soils at lower depths were more deficient in P than the surface soils. These results evinced that the surface soils were low (< 4.0 µg g-1 P) in 8, marginal (4.0 to 7.0 µg g-1 P) in 26 and adequate (>7.0 µg g-1 P) in 10 out of 44 orchards (Table 5). The subsurface soils were low in 33, marginal in 9 and adequate in 2 orchards. Thus, 18% orchards were low in P in the surface and 75% in subsurface. Similarly, 59% orchards were marginal in P in the surface and 20% marginal in subsurface while 23% orchards were adequate in P in the surface and 5% in the subsurface soils.

AB-DTPA extractable K in the soils varied with depth and from orchard to orchard location (Tables 4 to 5). The concentration of K was greater in the surface compared with that at lower soil depths. Potassium concentration in the surface ranged from 103 to 366 µg g^{-1} soil with the mean value of 217.95 ± 59.72. In subsurface, it ranged from 103 to 393 µg g^{-1} with mean of 182.70 ± 66.53. Comparing with the critical value of K in soil established by Soltanpour (1985), our data demon-strated that K was adequate in both soil depths of most of the orchards. It was evident that the soils at lower depths were more deficient in K than at the surface. In surface soil, K was 5 and 95%, while in subsurface it was 18 and 82% in marginal and adequate orchards, respectively.

Available micronutrients

AB-DTPA extractable micronutrients concentrations in the soils are presented in Tables 6 to 7. Their concentration in soils varied with depth and orchard location. Zinc concentration was higher in the surface soil but decreased with soil depth. It ranged in surface soil from 0.35 to 4.55 µg g^{-1} with a mean value of 2.04 ± 0.88 and in sub-surface, it ranged from 0.47 to 2.50 µg g^{-1} with mean of 1.49 ± 0.44.

Copper concentration in the surface soil ranged from 2.44 to 8.46 µg g^{-1} with mean of 5.61 ±1.69. In sub-surface, it ranged from 1.74 to 9.07µg g^{-1} with mean of 5.10 ± 1.54. Iron in surface soil ranged from 1.93 to 17.27 with mean of 6.49 ± 3.39. In the sub-surface, it ranged from 1.39 to 11.81 with mean of 6.17 ± 2.83. Manganese in surface soil ranged from 1.07 to 25.42 with mean of 11.30 ± 7.87. Similarly, in sub-surface, it ranged from 1.90 to 21.11 with mean of 8.62 ± 6.08. Boron in surface soil ranged from 0.016 to 1.32 µg g^{-1} soil with the mean value of 0.63 ± 0.30. In the sub-surface, it ranged from 0.018 to 1.42 µg g^{-1} with mean of 0.59 ± 0.31 µg g^{-1}.

Comparing these values with the critical values of micronutrients in soils established by Soltanpour (1985), our data showed that the soil were deficient in Zn, B and Fe at varying depth. Surface soils were low (<0.9 µg g^{-1}) in Zn in 4 (9%), marginal (0.9 to 1.5 µg g^{-1}) in 9 (20%) and adequate (> 1.5 µg g^{-1}) in 31 (71%) out of 44 orchards (Table 7). Sub-surface soils were low in Zn in 3 (7%), marginal in 21 (48%) and adequate in 20 (45%) orchards. All of the 44 orchards had adequate concen-tration of Cu (> 0.5 µg g^{-1}) and Mn (>1.0 µg g^{-1} soil). Similar results were also reported by Mohammad et al.

Table 6. Micronutrients concentration in the soils (µg g^{-1}) of guava orchards.

Micronutrient	Soil depth (cm)	Min	Max	Mean	SD
Cu	0-25	2.44	8.46	5.61	1.69
	25-45	1.74	9.07	5.10	1.54
Fe	0-25	1.93	17.27	6.49	3.39
	25-45	1.39	11.81	6.17	2.83
Mn	0-25	1.07	25.42	11.30	7.87
	25-45	1.90	21.11	8.62	6.08
Zn	0-25	0.35	4.55	2.04	0.88
	25-45	0.47	2.50	1.49	0.40
B	0-25	0.016	1.32	0.63	0.30
	25-45	0.018	1.42	0.59	0.31

Table 7. Relative proportions of guava orchards classified as low, marginal or adequate in micronutrients based on their concentrations in soils.

Nutrient	Soil depth (cm)	Low		Medium		Adequate	
		No. * of orchards	Percent	No. of orchards	Percent	No. of orchards	Percent
Cu	0-25	0	0	0	0	44	100
	25-45	0	0	0	0	44	100
Fe	0-25	7	16	8	18	29	66
	25-45	6	14	12	27	26	59
Mn	0-25	0	0	0	0	44	100
	25-45	0	0	0	0	44	100
Zn	0-25	4	9	9	20	31	71
	25-45	3	7	21	48	20	45
B	0-25	19	43	21	48	4	9.0
	25-45	18	41	23	52	3	7

* Out of 44 orchards

(1995). The results on Fe status showed that the surface soils were low (< 3.0 µg g^{-1}) in Fe in 7 (16%), marginal (3.0 to 5.0 µg g^{-1}) in 8 (18%) and adequate in 29 (66%) out of 44 orchards (Table 7). The sub-surface was low in 6 (14%), marginal in 12 (27%) and adequate in 26 (59%) orchards. It was evident that Fe was deficient in both surface and sub surface soils of most of the orchards.

In surface soil B was low (< 0.45 µg g^{-1}) in 19 and 18 orchards in surface and sub-surface soils, respectively. Twenty one orchards were marginal (0.45 to1.0 µg g^{-1}) in surface and 23 in subsurface soils. The B concentration in surface soil was adequate (1.0 µg g^{-1}) in 4 orchards and in 3 in subsurface. 43% of the orchards were low in B in the surface and 41% in sub-surface. Similarly, 48% of the orchards were marginal in the surface and 52% in subsurface. The surface soils were adequate in B in 9% of the orchards and 7 % in subsurface.

Nutritional status of guava trees

Table 8 shows that P concentration in the leaves of guava ranged from 0.03 to 0.21 µg g^{-1} with mean of 0.07± 0.02 µg g^{-1}. Leaf K ranged from 0.55 to 3.18 µg g^{-1} with the mean value of 1.54 ± 0.59. The concentration of micronutrients in the leaves varied greatly among orchards. Zinc concentration ranged from 10.37 to 87.04 µg g^{-1} with mean of 34.91 ± 14.28. Copper content ranged from 3.8 to 277.2 µg g^{-1} with mean of 15.87 ± 40.49. Iron concentration ranged from 37.96 to

Table 8. Nutrients concentration in leaves (µg g^{-1}) of guava orchards in Kohat district.

Nutrient	Min	Max	Average	SD
P	0.03	0.21	0.07	0.02
K	0.55	3.18	1.54	0.59
Zn	10.37	87.04	34.91	14.28
Cu	3.8	277.2	15.87	40.49
Fe	37.96	309.84	119.79	63.21
Mn	46.40	403.38	145.55	94.96
B	44	157	75.20	23.20

Table 9. Number of guava orchards classified as low, adequate or high in micronutrients based on leaf concentration.

Nutrient	Low		Adequate		High	
(µg g^{-1})	No.* of orchards	Percent	No. of orchards	Percent	No. of orchards	Percent
P	38	86	5	11	1	3
K	0	0	7	16	37	84
Zn	5	11	11	25	28	64
Cu	7	16	33	75	4	9
Fe	22	50	13	30	9	20
Mn	7	16	16	36	21	48
B	4	9	35	80	5	11
P	38	86	5	11	1	3
K	0	0	7	16	37	84

*Out of 44 orchards.

309.84 µg g^{-1} with mean of 119.79 ± 63.21. Manganese concentration ranged from 46.40 to 403.38 µg g^{-1} with mean of 145.55 ± 94.96. Boron concentration ranged from 44 to 157 µg g^{-1} with mean of 75.20 ± 23.20. Our results are in conformity with the findings of Shah and Shahzad (2008).

Comparing the values of leaf contents of nutrients with their critical values in guava leaves established by Hundal et al. (2007), it was demonstrated that leaf P was low (0.065 to 0.10 µg g^{-1}) in 38 (86%), adequate (0.10 to 0.17 µg g^{-1}) in 5 (11%) and high (0.17 to 0.21 µg g^{-1}) in 1(3%) orchards. Low K (0.28 to 0.51 µg g^{-1}) was not recorded in any orchards, and was adequate (0.51 to 0.9 µg g^{-1}) in 7 (16%) and high (0.97 to 1.19 µg g^{-1}) in 37 (84%) orchards. It was further observed that 11% of the orchards were low (8 to 15 µg g^{-1}), 25% adequate (15 to 29 µg g^{-1}) and 64% high (29 to 36 µg g^{-1}) in Zn (Table 9). Copper was low (1 to 6 µg g^{-1}) in 7 (16%), adequate (6-16 µg g^{-1}) in 33 (75%) and high (16 to 21 µg g^{-1}) in 4 (9%) orchards. Iron was low (82 to 105 µg g^{-1}) in 22 (50%), adequate (105 to 153 µg g^{-1}) in 13 (30%) and high (153 to 176 µg g^{-1}) in 9 (20%) orchards. Manganese was low (31 to 58 µg g^{-1}) in 7 (16%), adequate (58 to 110 µg g^{-1}) in 16 (36%) and high (110 to 136 µg g^{-1}) in 21 (48%) orchards. Boron was low in 9%, adequate in 80% and high in 11% of the orchards.

Correlation studies

There existed positive significant correlation of P, K, Cu, Fe and Mn with soil organic matter indicating that organic matter contributed to the major fraction of these nutrients in soils (Table 10). Similarly, Cu and Fe showed positive significant correlation with clay content of the soils. This suggests that Cu and Fe contents were higher in soils having higher clay content.

Nutrient availability and their uptake were also affected by the properties of soils particularly organic matter and clay contents. Plant P and Fe showed positive significant correlation with organic matter (Table 11) and plant K and Cu with clay content suggesting that soil organic matter and clay helped in the uptake of P, K, Cu and Fe.

Conclusions

Majority of soils were medium in texture with adequate organic matter content. Extractable P was deficient in 18% orchards with no K deficiency. Soil Zn was deficient in 9%, Fe in 16% and B in 43% orchards. Available Cu and Mn were adequate in the soils of all orchards. Soils of orchards found deficient in various nutrients should be fertilized in order to supply the needed nutrients.

Table 10. Correlation of soil nutrients with soil properties.

Soil nutrients/depth (cm)		Soil property			
		pH	OM	EC	Clay
P	0-25	0.105	0.420**	0.043	-0.110
	25-50	-0.269	0.181	0.145	-0.026
K	0-25	0.087	0.406**	-0.207	0.155
	25-50	0.060	0.074	-0.066	-0.204
Cu	0-25	0.163	0.245	-0.087	0.438**
	25-50	0.047	0.425**	-0.119	0.325*
Fe	0-25	0.003	0.171	0.155	0.273
	25-50	-0.235	0.389**	0.151	0.396**
Mn	0-25	0.197	0.315*	-0.353	-0.363
	25-50	0.226	-0.300	-0.177	-0.398
Zn	0-25	0.112	0.167	-0.002	0.176
	25-50	0.029	0.170	0.071	0.076
B	0-25	-0.252	-0.071	0.320*	0.216
	25-50	-0.253	0.068	0.184	0.370**

Table 11. Correlation of plant nutrients with soil properties.

Plant nutrients/ depth (cm)		Soil property			
		pH	OM	EC	Clay
P	0-25	0.020	0.402**	-0.004	0.137
	25-50	0.097	-0.029	0.135	0.191
K	0-25	-0.002	-0.099	0.038	0.267
	25-50	-0.110	0.269	0.204	0.458**
Cu	0-25	0.312*	-0.307	-0.118	0.188
	25-50	0.370*	-0.301	-0.048	0.545**
Fe	0-25	0.118	0.308*	-0.180	-0.322
	25-50	0.370*	-0.069	-0.157	-0.545
Mn	0-25	0.144	0.100	-0.242	-0.299
	25-50	0.199	-0.312	-0.217	-0.542
Zn	0-25	0.025	-0.023	-0.084	0.055
	25-50	-0.109	-0.209	0.224	-0.015
B	0-25	-0.146	0.144	0.020	-0.177
	25-50	0.011	-0.114	-0.184	-0.360

*$r_{0.05} = 0.298$; ** $r_{0.01} = 0.385$.

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