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MICRONUTRIENTS STATUS OF PEACH ORCHARDS IN SWAT VALLEY

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ABSTRACT

A survey was conducted to assess the Zn, Cu, Fe, Mn, and B status of 50 peach (Prunuspersical L.) orchards in Swat Valley of Khyber Pakhtunkhwa province during 2008. Soil at 0-15, 15-30 and 30-45 cm along with leaf samples were collected from each orchard and analyzed for micronutrients contents. The soil of surveyed orchards were either loam (38.3 %), silt loam (38.3 %), sandy loam (19.2 %), loamy sand (2.1 %) or clay loam (2.1 %) in texture and none of the soil samples at 0-15 cm was deficient in AB-DTPA extractable Cu, Zn, Fe, Mn or HCl extractable B. The lower depths (15-45 cm) were deficient in Zn and B only in 4-8 % peach orchards. The leaf tissue analysis showed that none of the orchards was low in Cu, Mn and Fe. However, B was deficient in 6 % and Zn in 2 % peach orchards. No or poor correlation was found between soil and plants tests for diagnosing micronutrient deficiencies in peach orchards. The significant correlation of surface soil (0-15 cm) with cumulative micronutrient contents of the profile (0-45 cm) revealed that the surface soil analysis can be used to measure pattern in micronutrients fertility of the profile. These results suggested that peach orchards in Swat valley are not yet seriously deficient in micronutrients but the deficiency is appearing. Therefore, these orchards should be assessed regularly for micronutrients status for timely management.

Keywords: **Micronutrients, nutrients critical level, peach orchards, soil properties**

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INTRODUCTION

Peach (*Prunuspersica* L.) belongs to the family Rosaceae, and is one of the most important fruit grown in the Khyber Pakhtunkhwa province of Pakistan. The soil and climatic conditions of Khyber Pakhtunkhwa in general and of Swat valley in particular are conducive to grow important fruit crops including apple, peaches, apricots and others. The soils of Swat valley are generally fertile. However, due to the adaptation of modern technology, per unit yield of fruit and other crops has increased. Therefore, plant nutrients are removed from soil at much faster rate than ever before and hence the soils are getting deficient both in major as well as micronutrients (Shah and Shahzad, 2008). A recent survey of citrus orchards in Swat valley showed a wide spread deficiency of Zn, B and Mn in citrus orchards (Shah *et al*., 2012).

The appearance of nutrient deficiency symptoms and responses to added nutrients indicated the prevalence of nutritional disorders of micronutrients (Zn, Cu, Mn and B) in the soils of Khyber Pakhtunkhwa (formerly known as North West Frontier Province- NWFP) (Rehman and Haq, 2006; Khattak and Hussain, 2007). In spite of the fact that the total quantities of micronutrients present in soil may be adequate, nutrients translocation does not match with growth or uptake (Shah *et al*., 2012). This phenomenon is very common in Pakistan in stone fruit plants, such as peach, apricot and plum, as reported elsewhere (Rehman, 1990). The deficiency or unavailability of micronutrients is probably the results of various factors such as introduction of high yielding cultivars, imbalance nutrients or excess of certain nutrients in soil through canal irrigation or through commercial fertilizers which may interfere with the availability and uptake processes of micronutrients due to chemical or physiological change (Tariq *et al., 2005*). A nutritional survey of orchards in Peshawar valley revealed deficiency of Zn (17 %), Cu (13%), Fe (45%), Mn (2%) and B (95%) in different orchards (Tariq *et al*., 2008). Micronutrients deficiency in fruit orchards were attributed mainly to soil conditions as the soils of these orchards were alkaline, non-saline, low in organic matter and were calcareous in nature (Tariq *et al*., 2008). Rahman*et al*. (2012) reported that improvement of soil properties through orchard floor management is a desired option to improve yields, increase nutrient availability and enhance water use efficiency.

Micronutrients are as important as macronutrients for optimum plant growth. The deficiency of micronutrients causes abnormal plant growth that result in partial or complete failure of crop plants. Grain and flower formation fails to develop in severe deficiency. Micronutrient deficiencies particularly of boron (Woodbridge, 1955) and zinc (Woodbridge, 1954) have long been reported to potentially cause major growth problems for apples grown in traditional apple orchards. Neilsen*et al.* (2006) reported that foliar application of Zn and B on apple orchards ameliorated B deficiency symptoms. In another study, the foliar application of zinc sulfate on apple trees during fruit development increased the concentration of Zn in leaf samples from 0.7 to 1.5 µg g^{-1}, and due to the role of Zn as an antioxidant, the browning of the treated apples was reduced (Malakouti, 2001). A number of studies in Pakistan have shown significant responses of fruit orchards to micronutrients application (Zia *et al*., 2006; Tariq *et al*., 2007; Rafiullah, 2010).

Evaluation of mineral nutritional requirements of fruit trees is different than that of annual crops because of large variation in rooting system. The fruit orchards have large and deep roots than annual crops and therefore require more deep soil sampling and analysis (de Villiers and Bayers, 1961). Nutrient deficiency can be determined through visual symptoms, soil test or plant analysis. Soil analysis has been reported to be of lesser value because of the tree roots penetration to the greater depth and encounters greater variation (Asher *et al*., 1983; Shah *et al*., 2012). Assessing the micronutrients status of soils and plants is one of the pre-requisite to known the deficiency of such nutrients in soils and for future planning to remove such deficiencies for enhanced production.

The peach plant requires both major and micronutrients in sufficient and balanced amount for optimum production of fruit. The farmers in Swat generally use major nutrients on their orchards and pay little attention to the use of micronutrients. Keeping in view the importance of nutritional requirements of micronutrients for peach orchards, this study was conducted to determine the micronutrients concentration both in soil and plant of peach orchards, and correlate the available micronutrients with important properties of peach orchards for nutrient indexation.

MATERIALS AND METHODS

A survey was conducted to assess the micronutrients status of 50 peach orchards in Swat valley of Khyber Pakhtunkhwa province, Pakistan during 2008. From each orchard, 10-15 random soil samples were collected at three depths such as 0-15, 15-30 and 30-45 cm depth. Soil samples of respective depths were composited, bagged and labeled. In this way each orchard had three soil samples. Soil samples were collected within the periphery of tree canopy. At the time of soil sampling, 120-150 representative leaf samples were also randomly collected from same orchard. For this, 12-16 fully matured leaves from current year growth branch / twig at about 1.5 m height from four quadrants per tree were collected. Leaf samples of same orchard were composited, bagged, labeled and transported to the lab.

Samples Processing

Soil samples were air dried in air in the laboratory and broken down by hand. The samples were passed through <2.00 mm sieve. The samples were then stored in plastic containers until ready to run for analysis. Within 24 hours of sampling, leaf samples were washed initially with tap water containing detergent and then with distilled water. After air-drying, leaf samples were dried in oven at 70 °C to constant weight and then grinded to poweder in a stainless steel Willey mill.

Laboratory Analysis

Determination of Micronutrients in Leaf Samples

The concentration of micronutrients (Zn, Cu, Fe, Mn) in leaf samples was determined using the wet digestion procedure (Rashid, 1986) as described in Ryan *et al.* (2001) with minor modifications. The boron (B) concentration in leaf samples was determined by dry ashing (Jones and Case, 1990) with subsequent measurement of B on spectrophotometer using Azomethine-H method (Bingham, 1982) at 420 nm on spectrophotometer (Lambda-35) after the required dilution.

Determination of Extractable Micronutrients in Soil

The soil samples were extracted with AB-DTPA solution by the method of Soltanpour (1985). The extract was read for Zn, Cu, Fe and Mn concentrations on Atomic Absorption Spectrophotometer. The concentration of extractable B in soil was determined by the dilute hydrochloric acid method using Azomethine-H for colour development as described in Ryan *et al*. (2001) at 420 nm on spectrophotometer (Lambda-35).

Other Soil Analysis

Other soil characteristic such as soil texture was determined by the Bouyoucos hydrometer method (Gee and Bauder, 1986). Soil pH and EC were determined in soil-water (1:5) suspension. For this purpose, 10 g soil sample was shaken with 50 ml distilled water for 30 min. After filtering, the extract was read for pH on pH meter (In Lab pH Level 1) and EC on EC meter (DDC-308A Conductivity Meter). Organic matter content was by the method of Walkely and Black (Nelson and Sommers, 1996).

Statistical Analysis

Descriptive statistics were used for calculation of means, standard deviations and coefficient of variations (Steel and Torrie, 1980). Nutrient status was compared with standard criteria for nutrient indexation.

RESULTS AND DISCUSSIONS

Micronutrient Concentrations in Peach Leaf Samples

Data obtained on micronutrient concentrations in leaf samples of peach orchards are presented in Table 1. The results showed that the concentration of micronutrients in leaf samples varied greatly among orchards. The Zn concentration in leaf samples ranged from as low as 22.2 ug g^{-1} to as high as 95.3 ug g^{-1} with a mean value of 41.6±14.8 Table 1. The Cu concentration in leaf samples ranged from 10.4 to 102.1 ug g^{-1} with a mean value of 19.41±12.45. The Fe concentration in leaf samples ranged from as low as 183 ug to as high as 971 ug g^{-1} with a mean value of 312±179. The Mn concentration in leaf samples ranged from 48.8 ug to 200 ug g^{-1} with a mean value of 119±39. The B concentration ranged from as low as 4 ug to as high as 661 ug g^{-1} with a mean value of 276±139.

Table 1. ***Range of micronutrients concentration in leaf samples of peach orchards in Swat valley***

Micronutrient	Concentration of micronutrients in peach leaves (ug g^{-1} DM)				%* of surveyed orchards classified as (based on critical nutrient concentration in peach leaves)		
	Mean	S.D	Minimum	Maximum	Low	Adequate	High
Zn	41.6	14.8	22.2	95.3	2	90	8
Cu	19.4	12.5	10.4	102.1	0	2	98
Fe	312	179	183	971	0	0	100
Mn	119	39	49	200	0	38	62
B	276	139	4	661	6	2	92

**Percent of total orchards (50) surveyed*

Comparing with the critical values of micronutrients in peach leaves established by Jones *et al.* (1991) and reported by Zia *et al.* (2004), our data revealed that 2% peach orchards were low, 90% adequate and 8% high in Zn Table I. Copper was adequate in 2% and high in 98% peach orchards. None of the 50 orchards surveyed was deficient in Fe. Manganese was adequate in 38% and high in 62% orchards. Boron was deficient in 6%, adequate in 2% and high in 92% orchards. The Fe concentrations in peach leaf samples were high in all 50 peach orchards.

Micronutrient Concentration in Soils of Peach Orchards

The data obtained on AB-DTPA extractable micronutrients in soils of peach orchards are presented in Table 2. The AB-DTPA extractable micronutrients in soils varied with depth and with orchards. The concentration of Zn in the 0-45 cm soil ranged from as low as 0.67 ug g^{-1} to as high as 66.25 ug g^{-1} soil with a mean value of 7.46±10.18 Table 2. Similarly, the extractable Cu in the 0-45 cm soil ranged from 0.75 ugto 12.75 ug g^{-1} soil with a mean value of 4.62±3.04. The concentration of Fe in the 0-45 cm soil ranged from 5.73 ug to 116.14 ug g^{-1} soil with a mean value of 27±18.97. The extractable Mn in the 0-45 cm soil ranged from 1.42 to 22.10 ug g^{-1} soil with a mean value of 7.95±4.97. The concentration of B in the 0-45 cm soil ranged from 0.44 ug to 6.89 ug g^{-1} soils with a mean value of 3.37±2.016. Comparing with the critical values of AB-DTPA extractable micronutrients in soil as reported in Jones *et al.* (1991) and Zia *et al.* (2004), our data revealed that the soils of 5% peach orchards were low, 6% marginal and 88% adequate in extractable Zn. Manganese was marginal in 2% and adequate in 98% orchards. Boron was low in 2%, adequate in 20% and high in 78% orchards. However, none of the 50 orchards surveyed was deficient in Cu and Fe.

Table 2. ***Range of AB-DTPA extractable micronutrients in 0-45 cm soil of peach orchards in Swat valley***

Micronutrient	Concentration of micronutrients in peach leaves (ug g^{-1} soil)				%* of surveyed orchards classified as (based on critical nutrient concentration in soil)		
	Mean	S.D	Min	Max	Low	Adequate	High
Zn	7.47	10.19	0.67	66.25	5	6	88
Cu	4.65	3.05	0.76	12.76	0	0	100
Fe	27.0	19.0	5.74	116.1	0	0	100
Mn	7.95	4.98	1.42	22.10	0	2	98
B	3.48	2.06	0.44	6.89	2	20	78

*Percent of total orchards (50) surveyed

Change in Micronutrient Concentration with Soil Depth

The results obtained on AB-DTPA extractable micronutrients in various soil depths are presented in Fig I. The results showed that the concentrations of AB-DTPA extractable Zn and Mn decreased gradually with increasing soil depth. However, the concentration of Cu and B did not change considerably with soil depth.

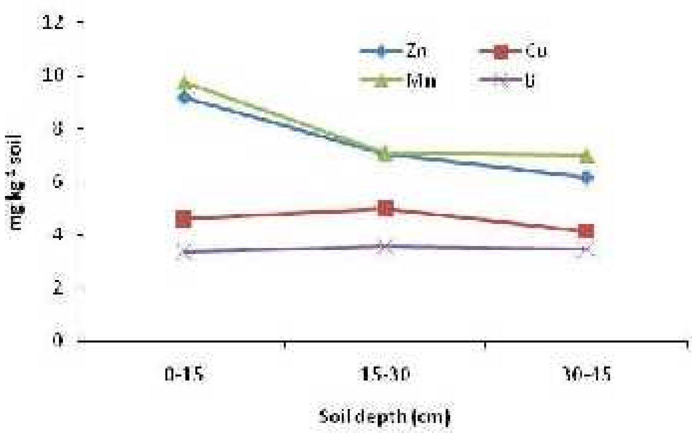

Fig. 1. Change in the concentration of extractable micronutrients with soil depth

Particle Size Distribution

The result obtained on particle size distribution in soil samples of peach orchards are presented below in Table 3. The sand content of soils ranged from 19.1 to 81.3% with mean value of 40.5 (± 13.6). The silt content of soils ranged from 12.7 to 77.4% with mean value of 49.2 (± 14.7) %. The data revealed that silt was the dominant fraction in most soils of peach orchards in Swat valley. The clay content of soils ranged from 2.13 to 29.87% with mean value of 10.30 (± 6.04) %. The data revealed that clay minimum in most soils of peach orchards in Swat valley. The textural classes of the soils of peach orchards in Swat valley varied from loam, silt loam, sandy loam and loamy sand to clay loam (Figure 2). However, the majority of soils of peach orchards were either loam or silt loam. Our data revealed that the soils of 18 out of 47 orchards were silt loam with similar number as loam, whereas 9 orchards were sandy loam with only one orchard each as loamy sand or clay loam.

Table 3. ***Particles size analysis (%) of soils of peach orchards***

Soil particle	Mean	S.D	Range	
			Minimum	Maximum
Sand	40.49	13.57	19.07	81.33
Silt	49.21	14.73	12.67	77.40
Clay	10.30	6.04	2.13	29.87

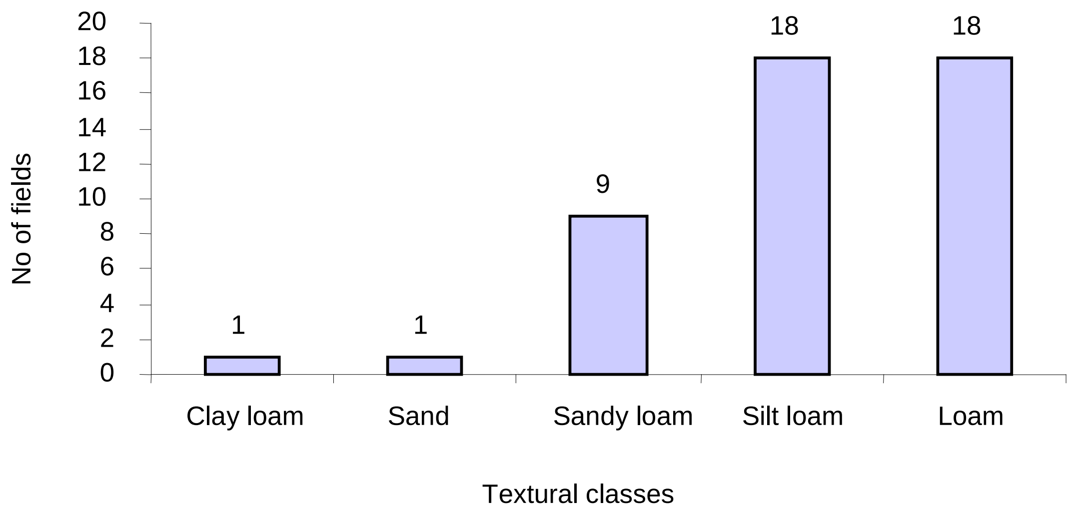

Fig. 2. Textural classes of soils collected from peach orchards

Correlation Analysis

Simple correlation coefficients between total profile (0-45 cm) and surface soil (0-15 cm) micronutrients contents showed that there was a strong correlation between surface soil and cumulative micronutrients contents of profile Table 4. Surface soil micronutrients contents seem to be an acceptable indicator of micronutrients fertility pattern in the profile (0-45 cm). Regression analysis of cumulative profile micronutrients contents with surface soil contents showed that R^2 approached unity with a slope of less than one (Fig IIIa-e). Variation in total profile concentration of micronutrients was accounted for 94% for B and 100% for Fe, Cu and Mn. This trend can be used to estimate micronutrient levels in the profile (0-45 cm) using regression equations parameters developed in this study Table 4. The prediction of micronutrients contents in the profile (0-45 cm) from the surface soil (0-15 cm) analysis using the regression equations developed in this study will certainly save time, labour and chemicals in future.

Table 4. ***Coefficients of regression equation enabling to determine the profile (0-45 cm) micronutrients from the surface (0-15 cm) concentration***

Micronutrients kg ha^{-1} soil (0-45 cm)	a (intercept)	b (slope)	R^2
Zn	0.143	0.814	0.95
Cu	0	0.333	1.00
Fe	0	0.333	1.00
Mn	0	0.333	1.00
B	0.206	0.963	0.94

Crop require balanced amount of both major and minor nutrients for optimum yield. Balance nutrition is possible only when nutrient status of the soil is known. The peach farmers in Pakistan are mostly using major nutrients on their farms with no or negligible amount of micronutrients despite the fact that micronutrients are as important for plant growth as major nutrients. This study was conducted to assess the micronutrient status of peach orchards in Swat for better management of orchards in terms of fertilizer application. The soil and plant analysis revealed that micronutrients concentrations varied greatly in peach orchards. The leaf analysis showed that that peach orchards were mostly sufficient in micronutrients. Only few of the surveyed orchards were deficient in Zn (2%) and B (6%). The soil analysis showed almost similar trend indicating that only 5 % orchards were deficient in Zn and 2 % in B whereas the soils of remaining orchards had adequate concentration of micronutrients. These results are contrary to the earlier reports where the soils of Swat region were generally deficient in micronutrients (e.g., Shah and Shahzad, 2008; Shah *et al*., 2012) and the deficiency of micronutrients are on the rise. These differences could be due to different cropping as Shah and Shahzad (2008) worked on apple and Shah *et al*. (2012) on citrus in the same region. Moreover, in this study the soil and plant test showed good correlation. This is contrary to many of the published literature where poor correlation between soil and plant nutrient levels in fruit plants

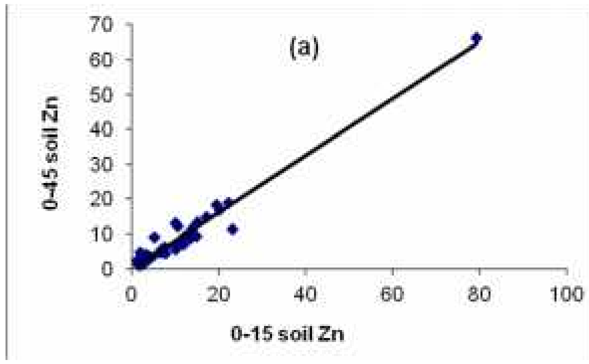

Fig. 3(a) Correlation between 0-15 and 0-45 cm soil Zn (ug g^{-1})

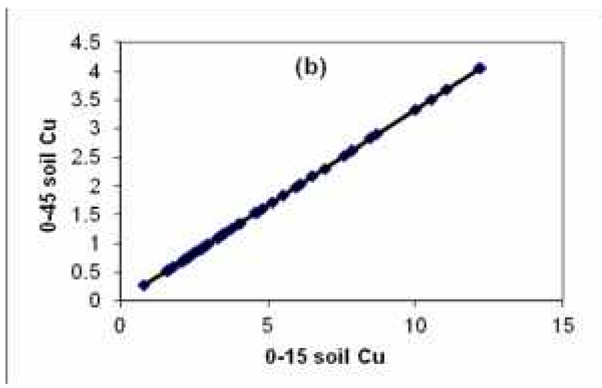

Fig. 3(b). Correlation between 0-15 and 0-45 cm soil Cu (ug g^{-1})

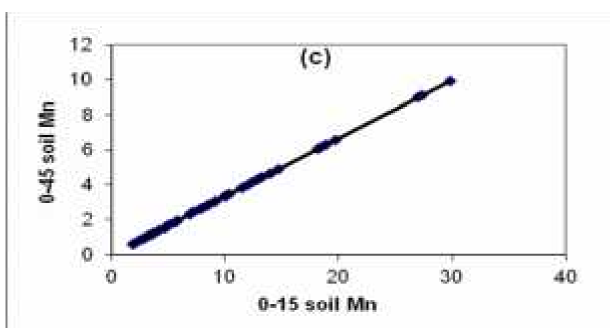

Fig. 3(c) Correlation between 0-15 and 0-45 cm soil Mn (ug g^{-1})

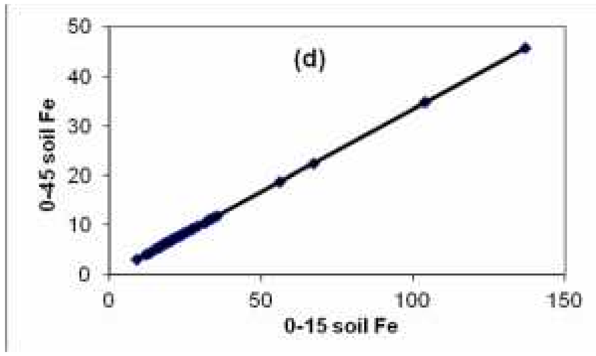

Fig. 3(d) Correlation between 0-15 and 0-45 cm soil Fe (ug g^{-1})

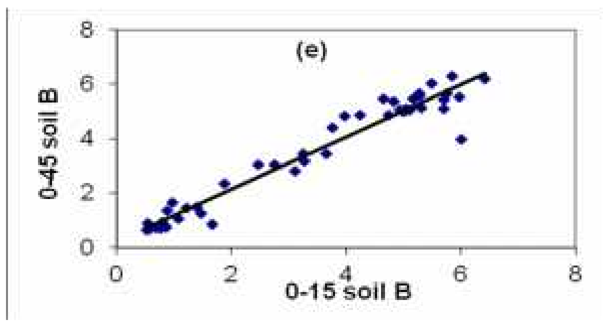

Fig. 3(e) Correlation between 0-15 and 0-45 cm soil B (ug g^{-1})

have been reported elsewhere in Pakistan (Zia *et al*., 2004; Aziz *et al*., 2004; Ibrahim *et al*., 2004; Shah and Shahzada, 2008; Shah *et al*., 2012). Aziz *et al*. (2004) suggested that soil tests have limited values for fruit trees because of difficulty in obtaining representative soil samples from varying rooting zone. Also soils differ greatly in characteristics (soil pH, soil EC, moisture content, organic matter content, mineral contents) and such variation influences the availability of nutrients in soil (Zia *et al.*, 2004). We however observed strong correlations between micronutrient contents in the surface soil (0-15 cm) and the cumulative micronutrients contents of the profile (0-45 cm). These results suggest that the surface soil analysis can be used to measure pattern of micronutrients fertility of the whole soil profile. This trend can be used to estimate the micronutrient concentration in the soil profile (0-45 cm) using regression equations parameters developed in this study. The prediction of micronutrients fertility in the profile (0-45 cm) from the surface soil (0-15 cm) analysis using the regression model developed will be of great use in saving time, labor and chemicals in future. Shah and Shahzad (2008) and Shah *et al.* (2012) have reported similar findings for prediction of micronutrients in the profile from the surface soil analysis through regression equations in apple and citrus orchards in Swat valley.

CONCLUSION AND RECOMMENDATIONS

Peach orchards in Swat were generally sufficient in micronutrients based on leaf analysis. Only 2% peach orchards were deficient in Zn and 6% in B. The soils of peach orchards were silt loam and loam in texture.
Although micronutrients are currently sufficient in peach orchards but their deficiencies are appearing. It is therefore recommended that farmers must include micronutrients in fertilizers application to peach orchards in Swat.

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REFERENCES

Aziz, T., M.A. Gill, Rahmatullah and M. Sabir. 2004. Mineral nutrition of fruit trees. p. 28-33. *In* M. Ibrahim (ed.), Proceedings of Symposium on Plant-Nutrition Management for Horticultural Crops under Water-Stress

Conditions, organized by Soil Science Society of Pakistan, Agriculture Research Institute (ARI), Sariab, Quetta, and PSF on October 5-6, 2004 at ARI Sariab, Quetta, Balochistan.

Asher, C.J., F.P.C. Blamey and C.P. Mamaril. 1983. Sulphur nutrition of tropical annual crops. Pp. 54-64. *In*: Blarir, G.J. and A.R. Till (eds.), Sulfur in S.E. Asian and S. Pacific Agri. Indonesia. UAE.

Bingham, F.T. 1982. Boron. P. 431-448. *In* Methods of Soil Analysis Part-2 Chemical and mineralogical properties (A.L. Page (ed.), ASA, Madison, WI, USA.

de Villiers, J.I., and C.J. Beyers. 1961. Leaf analysis as a guide to fertilization in commercial orange growing. Pp. 107-119. *In*: W. Reuther, (ed), Plant Analysis and Fertilizer Problems. Publication No.8 American Institute of Biological Sciences, Washington

Gee, G. W. and J. W. Bauder. 1986. Particle-size analysis. In Methods of Soil Analysis Part 1-Physical and mineralogical methods, 2nd edition, ed., A.L. Page, 383-411. Agronomy Monograph 9, American Society of Agronomy, Madison, WI.

Ibrahim, M., N. Ahmad, A. Niaz and M.Y. Nadeem. 2004. Micronutrient status of soils and citrus orchards of citrus growing area. p. 88-94. *In* M. Ibrahim (ed.), Proceeding of Symposium on *Plant-Nutrition Management for Horticultural Crops under Water-Stress Conditions*, organized by Soil Science Society of Pakistan, Agriculture Research Institute (ARI), Sariab, Quetta, and PSF on October 5-6, 2004 at ARI Sariab, Quetta, Balochistan.

Khattak, R.A. and Z. Hussain. 2007. Evaluation of soil fertility status and nutrition of orchards. Soil Environ. 26(1):22-23.

Jones, J.B. Jr. and V.W. Case. 1990. Sampling, handling, and analyzing plant tissue samples. Page 389-428 *In* R. L. Westerman (ed.), Soil Testing and Plant Analysis. SSSA Book Series: 3. SSSA, Inc., Madison, Wisconsin, USA.

Jones, J.B. Jr., B. Wolf and H.A. Mills. 1991. Plant Analysis Handbook. Micro Macor Publishing, Inc., USA.

Malakout, M. J. 2001. The effects of balanced fertilization and zinc application on improving apple yield, quality, and reducing browning incidence. *In*Neilsen, D., B. Fallahi, G. Neilsen and F. Peryea (eds). ISHS ActaHolticulturae 564.VI Inter. Symposium on Mineral Nutrition of Deciduous Fruit Crops.30 October 2001, Penticon, British Columbia.

Neilsen, G. H., D. Neilsen, E.J. Hogue and L.C. Herbert. 2006. Zinc and boron nutrition management in fertigated high density apple orchards. Can. J. Plant Sci. (Website address; http://www.actahort.org/books/564/index,htm).

Nelson, D.W. and L.E. Sommers. 1996. Total carbon, organic carbon, and organic matter. In Methods of Soil Analysis Part.3- Chemical Methods, ed., D.L. Sparks, 961-1010.SSSA Book Series No. 5.SSSA, Inc., ASA, Inc., Madison, Wisconsin, USA.

Rafiullah. 2010. Effect of foliar application of micronutrients on the yield and quality of plum (*Prunusdomestica* L.). M.Sc (Hons) thesis submitted to Department of Soil and Environmental Sciences, The University of Agriculture, Peshawar, Pakistan.

Rahman, H.U., G. Nabi, I. Ali, T. Tahir and M. Ahmad. 2012. Growth and yield of Kinnow (*Citrus reticulate Blanco*) and soil physical properties as affected by orchard floor management practices in Punjab, Pakistan. Soil Environ. 31(2): 163-170.

Rashid, A. 1986.Mapping zinc fertility of soils using indicator plants and soils-analyses.Ph.D Dissertation, University of Hawaii, HI, USA.

Rehman, H. 1990. Survey of the fruit plants for nutrient elements content and planning of fertilizer research programme.Annual report, Directorate of Soil and Plant Nutrition.Agriculture Research Institute of Tarrnab, Peshawar.

Ryan, J., G. Estefan and A. Rashid. 2001. Soils and Plant Analysis Laboratory Manual. Second Edition, Jointly published by the International Center for Agricultural Research in the Dry Areas (ICARDA) and the National Agricultural Research Center (NARC), available from ICRADA, Aleppo, Syria, x+172 pp.

Rehman, H. and I. Haq. 2006. Diagnostic criteria of micronutrients for sweet orange. Soil Environ. 25(2):119-127.

Shah, Z. and K. Shahzad. 2008. Micronutrients status of apple orchards in Swat valley of NWFP of Pakistan. Soil Environ. 27(2): 123-130.

Soltanpour, P. N. 1985. Use of NH_4HCO_3–DTPA soil test to evaluate elemental availability and toxicity.Communications in Soil Science and Plant Analysis. 16: 323-338.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. A bio-material approach. McGraw-Hill, New York, 2nd edition. Pages 633.

Tariq, M., K.M. Kakar and Z. Shah. 2005. Effect of boron-zinc interaction on the yield, yield attributes and availability of each to wheat (*Triticumaestvum L.*) grown on calcareous soils. Soil Environ. 24(2): 103-108.

Tariq, M., M. Sharif, Z. Shah and R. Khan. 2007. Effect of foliar application of micronutrients on the yield and quality of sweet ornage (*Citrus sinensis* L.). Pakistan Journal of Biological Sciences. 10(11): 1823-1828.

Tariq, M., Z. Shah and A. Ali. 2008. Micronutrients status of plum orchards in Peshawar valley. Soil Environ. 27(2): 223-227.

Woodbridge, C. G. 1954. Zinc deficiency in fruit trees in the Okanagan Valley in British Columbia. Canadian J. Agric. Sci. 34: 545-551.

Woodbridge, C. G. 1955. The boron requirements of stone fruit trees.Canadian Journal of Agriculture Sciences. 35: 282-286.

Zia, M.S., M. Aslam, N.M. Cheema, A. Shah and H. Laghari. 2004. Diagnosis of plant nutrient disorder in fruit plants. P. 16-27. *In* Proceedings of Symposium on Plant-Nutrition Management for Horticultural Crops under Water-Stress Conditions (M. Ibrahim, ed.), organized by SSSP, ARI, Sariab, Quetta, and PSF on October 5-6, 2004 at ARI Sariab, Quetta, Balochistan.

Zia, M.J., R. Ahmad, I. Khaliq, A. Ahmad and M. Irshad. 2006. Micronutrient status and management in citrus orchard soil: Applied aspect. Soil Environ. 25(1): 6-16.