Proceedings:
International Symposium on
Prospects of Horticultural Industry in Pakistan
28th to 30th March, 2007
Institute of Horticultural Sciences, University of Agriculture, Faisalabad

STUDIES ON SOIL AND PLANT MICRONUTRIENTS RELATIONSHIP OF MANGO ORCHARDS IN HYDERABAD DISTRICT OF PAKISTAN

Nazila Azhar[1]*, Muhammad Yasin Ashraf[2], M. U. Shirazi[3], Muhammad A. Khan[3], Muhammad Aslam Pervez[1] and S. Ahmad[4]
[1]*Institute of Horticultural Sciences, University of Agriculture, Faisalabad
[2]Stress Physiology and Plant Biochemistry Lab, Nuclear Institute for Agriculture and Biology, P.O. Box 128, Jhang Road, Faisalabad, Pakistan.
[3] Plant Physiology Division, Nuclear Institute of Agriculture, Tandojam, Pakistan.
[4] Department of Crop Physiology, University of Agriculture, Faisalabad.
*Email: nazilabot@yahoo.com

Abstract

Hyderabad is an important mango producing district of Sindh province of Pakistan. Micronutrients have special role in plant and human life as they control a number of metabolic processes. To determine relationship between soil and plant micronutrients, an experiment was conducted in some mango orchards of Hyderabad. Micronutrients (Zn, Cu, Mn and Fe) in soil were determined by DTPA-$CaCl_2$ extraction and in plant by HNO_3:$HClO_4$ (1:5 ratio) digestion method. It was observed that zinc concentration was at low level (0.16-0.52 μg g^{-1}) in all the soils under study, however the levels of Fe and Mn were quite sufficient i.e. 7.34-10.63 μg g^{-1} and 6.90-14.15 μg g^{-1}, respectively. Cu concentrations were also sufficient (2.16-4.99 μg g^{-1}), except at a few places where soil was deficient (i.e. < 1.0. μg g^{-1}) at lower depths. Very similar with soil analysis, the micronutrients analysis in plants revealed that they were quite deficient in Zn (4.5-41.1 μg g^{-1}). Likewise, Mn (11.8-86.2 μg g^{-1}) was also quite unsatisfactory in many orchards. In spite of its sufficient level in soil, low values of Mn in plant leaves, might be due to conversion of Mn in to manganese oxides at high pH, resulting in less availability to plant. Contrary, Fe contents (27.8 to 428.3 μg g^{-1}) were quite adequate, whereas Cu values were little bit higher in plant (i.e.21.5 to 82.2 μg g^{-1}), ranging towards the toxic limits. From the data it is obvious that low status of Zn in soil and plants have urgent need for this nutrient, to be supplied to the plants. Besides Zn, Mn contents were also found low in plant leaves, therefore application of Zn and Mn as foliar spray is suggested for optimum metabolic activity and fruit yield.

INTRODUCTION

Nature has blessed Pakistan with wide range of agro-climatic conditions, which suite for the production of a variety of both tropical and temperate fruits. Among them mango is known as “King of the Fruits” and Nectar of God, being most palatable and rich in sugars, organic acid and minerals and thus captures great demand for all walks of life. Most of the authorities believe that

India, Bangladesh, Burma and further away Malayan Archipelago are the regions where it possibly took its origin (Ashraf, 2007).

Mango like all plants has certain requirements for its normal growth and rich fruiting. Some of these factors like climate are difficult to be controlled while other viz. essential elements and water can be easily managed by using scientific methods (Sukthumrong et al., 2000; Ashraf et al., 2006). The soils of Hyderabad are mostly formed from the alluvium deposited by the river Indus, passing about 8-10 km towards the east. The soils of Hyderabad, Pakistan are mostly fertile and contain sufficient macro- and micronutrients. Being calcareous in nature and under arid climate, the soils are mostly alkaline in reaction, are quite adequate in macronutrients but the availability of micronutrients at many places have become very low to meet the plant requirements (Sherazi et al., 2006). This situation has become more prominent in the recent years, when soils are being explored intensively by growing high yielding varieties of crop plants. If the supply of an essential trace element is inadequate, the growth of plant will be abnormal or stunted and it's further development, especially its metabolic cycle, are disordered which ultimately reduce fruit yield. Therefore it is necessary to evaluate the soil fertility status of this important fruit crop and to enhance the yield of mango through balanced fertilization, particularly trace elements. Hence an experiment was conducted in different mango orchards of Hyderabad, Pakistan to study the micronutrient status in soil and plants of mango orchards for proper micronutrient management to obtain high fruit yield with good quality.

MATERIALS AND METHOD

To assess the micronutrients status of mango orchards, a detailed survey was conducted in different mango orchards of Hyderabad. Sampling was done at immediate vicinity of mango trees (i.e. 1-2 m away from the main tree trunk). Soil samples were collected after exposing the profile up to 1 meter depth at a distance of 0-20, 20-40, 40-60 and 60- 100 cm, with the help of wooden spatula to avoid the contamination of iron or other minerals. Samples were dried and grinded for physic-chemical analysis. Soil texture was determined by Bouyoucos hydrometer method (Bouyoucos, 1962), EC, pH and $CaCO_3$ by Jackson, (1962) and micronutrients (Cu, Zn, Mn and Fe) were determined by Atomic Absorption Spectrophotometer (AAS), after extracting with DTPA-$CaCl_2$ extracting solution (Jackson, 1962).

Plant (fully developed leaf) samples were also collected from the same trees around the umbrella of the tree. Leaf samples were washed (first by tap water and then by distilled water), dried under the shed and then in an oven up to 72 hours. Leaf samples were grinded in the grinder to pass through 0.2 mm sieve. Plant samples were digested in HNO_3: $HClO_4$ (1:5) mixture at hot plate. The digested samples were also analyzed for micronutrients (Cu, Zn, Mn and Fe) by AAS after running suitable standards (Jackson, 1962).

Table 1: Physio-chemical properties of the mango orchards surveyed

Depth (cm)	Texture			ECe (1:5)	pH	$CaCO_3$ (%)	Organic matter (%)
	Heavy Soil (%)	Medium Soil (%)	Light Soil (%)				
0-20	64	32	4	0.10-0.45	7.62-8.55	3.0-7.6	0.90-2.20
20-40	60	36	4	0.10-0.90	7.75 -8.52	4.5-10.6	0.41-1.30
40-60	40	32	28	0.10-0.65	7.77- 8.40	4.2-10.2	0.12-0.85
60-100	44	32	24	0.10-0.90	7.71- 8.46	3.9-12.2	0.21-0.85

RESULTS AND DISCUSSION

The data for different physio- chemical analysis is pooled into Table 1. It was observed that most of the soil under study were heavy to medium in texture (Clayey to Clay loam), calcareous in nature (6.20-7.00%), non-saline (0.1-0.90 dS m^{-1}), alkaline in reaction (7.62-8.55) and low in organic matter (0.12-2.20%).

MICRONUTRIENTS IN SOIL

The observations, for the concentration of copper, zinc, manganese and iron in soil are presented in Table 2.

Copper (Cu)

Copper content in soil decreased with the increase in soil depth. Average extractable Cu was 4.99, 3.31, 2.16 and 2.18 μg g^{-1}, at 0-20, 20-40, 40-60, 60-100 cm depth, respectively (Figure 1a). According to Kabata and Pendias (2004), the common characteristic of Cu distribution in soil profile is its accumulation in the top horizons. This phenomenon is an effect of various factors, but above all Cu concentration in surface soil reflects the bio-accumulation of the metal and also recent anthropogenic source of the element. The data when compared with the critical levels suggested by Sillan Paa (1982) i.e. 0.8 to 1.0 μg g^{-1}, it was revealed that Cu concentration in all the soils, at surface layers were quite adequate. The findings are in accordance with the investigations made by Memon (1985) who reported that soils in Hyderabad were adequate in Cu content at surface layer 0-30 cm depth.

Zinc (Zn)

Generally zinc deficiency prevails more severely in alkaline and calcareous soils. According to Kabata and Pendias (2004) solubility and availability of Zn, is positively correlated with Ca saturation and P compounds present in soils. This relationship may reflect adsorption and precipitation processes as well as interaction between these elements**.** Soil profiles under study are invariably calcareous thus it showed that 96% samples were zinc deficient. The results confirmed the work of earlier researchers like Sillan Paa (1982) who during his global study reported 100% zinc deficiency in soils of Sindh. Where as, Memon (1985) found 60% soils of Hyderabad low in Zn. All the soil samples were below the critical level (Figure 1b) i.e. 0.6 μg g^{-1} (Lindsay and Norvell, 1978). Average values of Zn in soils were 0.52, 0.28, 0.20 and 0.16 μg g^{-1} at 0-20, 20-40, 40-60 and 60-100 cm, respectively.

Manganese (Mn)

Average Mn content in soil was found as 14.15 μg g^{-1} (0-20 cm), 10.75 μg g^{-1} (20- 40 cm), 7.60μg g^{-1} (40-60 cm) and 6.09 μg g^{-1} (60-100 cm) depth (Figure 1c). All the soil samples were quite rich for Mn content, when compared with the critical levels, as suggested by Lindsay and Norvell (1978), i.e. 1.0 μg g^{-1}. The results observed by Khanzada (1970) and Memon (1985) were also similar, who noticed that soils of Hyderabad are quite adequate in manganese. The effect of pH on the availability of Mn was not observed in the present work.

Table 2: Soil profile showing adequacy for different micronutrients (%)

Micro-nutrients	Critical level μg g^{-1}	Depth (cm)			
		0-20 cm	20-40 cm	40-60 cm	60-100 cm
Copper	1.0	100	92	68	84
Zinc	0.6	12	0	0	0
Manganese	1.0	100	100	100	100
Iron	2.5	100	100	100	100

*Critical levels according to Lindsay and Norvell, 1978, and Sillan Paa 1982

Iron (Fe)

Average values of Zn in soils were 10.63, 8.57, 7.34 and 7.92 µg g^{-1} at 0-20, 20-40, 40-60 and 60-100 cm respectively (Figure 1d). Comparison of Fe content with the critical level suggest by Lindsay and Norvell (1978) i.e. 2.5 µg g^{-1}, showed that 99% soil samples were quite sufficient in this element. The results were in agreement with that of Khanzada (1970) who found sufficiently high exchangeable iron ranged from 11.7 to 14.87µg g^{-1}, in soil of Tandojam Hyderabad. Similarly, Memon (1985) also reported that Fe in the soils of Hyderabad was adequate.

MICRONUTRIENTS IN PLANT

The data regarding the micronutrient status in mango leaves is presented in Table 3.

Copper (Cu)

Copper concentration in plant samples was ranged between 21.50 to 82.2 µg g^{-1} with an average concentration of 38.72 µg g^{-1}. Maximum Cu concentration was recorded at site no. 25, where the Desi variety was growing, aging of only 40 years; whereas the minimum Cu concentration was observed at site no. 8 in Langra mango variety of an age of 22 years. The over all data did not show any relation with respect to age and variety of mango crop. However all the values are ranging towards the toxic limit as suggested by Reuter and Robinson (1986), i.e. 20 µg g^{-1}.

Table 3: Micronutrients in plants (µg g^{-1})

Site No.	Age	Variety	Cu	Zn	Mn	Fe
1.	24 Years	Langra	27.2	10.4	30.0	166.2
2.	35 Years	Sindhri	48.5	41.1	31.0	275.1
3.	25 Years	Sindhri	27.1	8.1	24.6	359.5
4.	30 Years	Desi	32.7	10.6	44.8	521.3
5.	10 Years	Desi	39.3	7.5	60.2	324.1
6.	10 Years	Sindhri	38.3	11.2	42.9	239.1
7.	22 Years	Bangan Pali	35.8	12.3	38.0	184.0
8.	22 Years	Langra	21.5	4.5	29.3	215.6
9.	1.5 Years	Blackwhite Siroli	27.8	8.7	26.4	27.8
10.	30 Years	Siroli	33.2	11.4	45.2	241.7
11.	30 Years	Gulab Khas	43.1	12.8	35.0	241.5
12.	20 Years	Langra	16.6	14.0	38.0	277.7
13.	20 Years	Siroli	22.0	23.5	26.4	154.9
14.	30 Years	Gulab Khas	53.2	32.8	28.7	428.3
15.	25 Years	Fazli	53.3	12.1	53.1	219.5
16.	30 Years	Anokhla Sarda	46.3	10.2	35.7	219.9
17.	20 Years	Neelum	38.0	12.9	16.8	114.4
18.	45 Years	Desi	27.6	5.7	28.5	233.0
19.	45 Years	Desi	45.2	11.1	11.8	234.0
20.	30 Years	Desi	42.6	12.6	20.2	84.5
21.	18 Years	Black Seroli	33.7	7.2	43.1	223.0
22.	8 Years	Sindhri	35.5	13.6	29.9	162.8
23.	8 Years	Siroli	38.3	14.5	86.2	244.0
24.	12 Years	Sindhri	59.2	20.1	50.0	249.0
25.	40 Years	Desi	82.2	22.0	54.8	251.8
Average			38.72	14.03	37.22	245.4

Zinc (Zn)

Like in case of soil samples the concentrations of Zn in plants were also below the limits as reported by Reuter and Robinson (1982), i.e. 20 µg g^{-1} except only at five sites (2,13,14, 24 and 25), showing comparatively higher concentration. Maximum Zn contents (41.1µg g^{-1}) were observed at site no. 2 where variety Sindhri of 35 years was growing. Minimum Zn contents (4.5 µg g^{-1}) were recorded in Langra variety at the age of 22 years. Different varieties, which were sampled, did not show any significant change in Zn content.

Manganese (Mn)

The situation in case of Mn was quite different; in spite of its sufficient concentration in soil the concentration of Mn in plants was low. There was only one site (i.e. site no. 23), which showed sufficient Mn in plant samples. The contents of Mn in plant leaves might be due to conversion of Mn in to manganese oxides at high pH, resulting in less availability to plant (Ashraf et al., 2005). The Mn concentration in plant leaves ranged between 11.8 to 86.2 µg g^{-1}, with average values of 37.22 µg g^{-1}. According to Reuter and Robinson 1986, the adequate concentration of Mn in mango leaves is ranged between 60-500 µg g^{-1}, whereas, Malik et al. (1962) have the opinion that Mn concentration of about 800 µg g^{-1}, creates toxic effects in mango.

Iron (Fe)

The observation for Fe contents revealed that the mango trees were free of Fe deficiency. Mango plants were well nourished with this element, containing 27.8 to 428.3µg g^{-1} Fe with an average concentration of 245.4 µg g^{-1}. Iron content in mango leave at all sites is above the adequacy limit (i.e. 70-200 µg g^{-1}), as described by Reuter and Robinson (1986). Like other elements the age and variety of mango did not show any significant effect on Fe contents in plants

CONCLUSION

From the results it can be concluded that by analyzing soil and leaf samples in mango orchards the nutrient deficiency can be managed and by applying deficient nutrients specially micronutrients fruit yield, quality and plant health can be improved.

REFERENCES

Ashraf, M.Y. 2007. Variation in nutritional composition and growth performance of some halophytic species grown under saline conditions. African Journal of Range & Forage Science, 24:19-23.

Ashraf, M.Y., A. Khan, M. Ashraf and S. Zafar. 2006. Studies on the transfer of mineral nutrients from feed, water, soil and plants to buffaloes under arid environments. Journal of Arid Environments, 65:632-643.

Ashraf, M.Y., A.K. Alvi, G. Sarwar, M.S. Qureshi, M. Ashraf, and M. Hussain. 2005. Effect of ammonium chloride on the growth and nutrient uptake by cotton grown in alkaline soil. Agrochimica, XLIX:153-163.

Bouyoucos, G. J. 1962. Hydrometer method improved for making particle size analysis of soil. Agronomy J., 54:464-465.

Jakson, M.L. 1962. Soil Chemical Analysis. Pub. Constable ad Company Ltd., England.

Kabata, A. P. and H. Pendias. 2004. Trace Elements in Soils and Plants. CRC Press Boca Raton London, New York, Washington, D.C.

Khanzada, S.K. 1970. Status of some micronutrients elements of the soils of Agriculture Research Institute, Tandojam. M.Sc. (Thesis) submitted to University of Sindh, Jamshoro.

Lindsay, W.L. and W.A. Norvell. 1978. Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Sci. Amer. Proc. pp 42-45.

Malik, P.C., R.K. Sahaya and D.L. Singh. 1962. Effect of excess Mn on mango plants. Proc. Acad. Agric. Sci., 8 & 9:121-124.

Memon, K.S. 1985. Cooperative research programme on micronutrient status of soil. IInd Annual Report. Dept. of Agric. Chem., SAU, Tandojam.

Shirazi, M.U., Khan, M.A., Ali, M., Mujtaba, S.M., Mumtaz, S., Ali, M., Khanzada, B., Halo, M. A., Rafiq, M., Shah, J.A., Jafri, K.A. and Depar, N. 2006. Growth performance and nutrients of some salt tolerant multipurpose tree species growing under saline environment. Pak. J. Bot., 38:1381-1388.
Reuter, D.J. and J.B. Robinson. 1986. Plant Analysis (an international manual). Kata Press Proprietary Limited Melbourne and Sidney.
Sillan Paa, M. 1982. Micronutrients and nutrients status of soil, a global study. F.A.O. Soil Bull., 48 Rome.
Sukthumrong, A., Boonkerd, N., Khumlert, R., Feungchan, S., Luksanawimol, P., Prasittikhet, J. and Suriyapan, O. 2000. Plant nutrient and distribution under different fertilizer management in Nam Dok Mai. Acta Hort. 509:307-314.

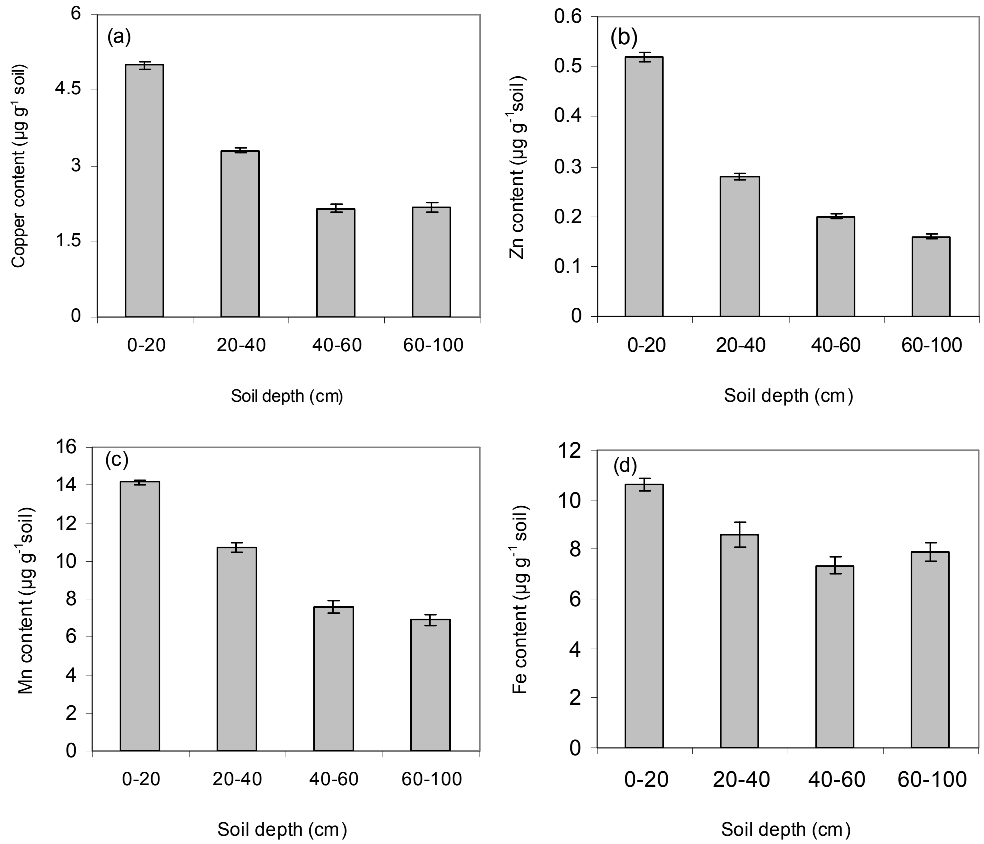

Figure 1: a (Cu), b (Zn), c (Mn), d (Fe) contents in different mango orchards of Hyderabad district