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MICRONUTRIENT AVAILABILITY ASSESSMENT OF TOMATO GROWN IN TALUKA BADIN, SINDH

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Abstract

This study was conducted to assess the micronutrient status of soils and associated plant tissues in major tomato growing areas of Taluka Badin, Sindh. Composite soil and plant (3rd leaf from top) samples were collected from 32 major growing areas of Taluka Badin and analyzed for copper (Cu), iron (Fe), manganese (Mn), zinc (Zn) and boron (B) along with selected physico-chemical properties of soils. Majority of the soils were clayey in texture (81%), non-saline (80%), alkaline and poor in organic matter. All soils were adequate in AB-DTPA extractable Cu (>0.5 mg kg^{-1}), Fe (>4 mg kg^{-1}), and Mn (>1.8 mg kg^{-1}) contents. Whereas AB-DTPA extractable soil Zn and hot-water soluble B values varied in a different way. Sixty six percent soils were low (<1.0 mg kg^{-1}), 28% marginal (1.0-1.5 mg kg^{-1}), and only 6% were adequate (>1.5 mg kg^{-1}) in soil Zn. Ninety one percent samples were low (<0.5 mg kg^{-1}) and only 9% were adequate (>1.0 mg kg^{-1}) with regard to B. The data regarding plant analysis depicted that all samples were high in Fe (> 200 mg kg^{-1}), whereas Cu was high (> 20 mg kg^{-1}) in 19% samples and sufficient (5-20 mg kg^{-1}) in 81% samples. Manganese was sufficient (40-250 mg kg^{-1}) in 94% samples and low (30-39 mg kg^{-1}) in 6% samples. Plant Zn analysis showed that 53% samples were high (>50), 22% samples sufficient (20-50 mg kg^{-1}) and 25% low (18-19 mg kg^{-1}) in Zn supply. Plant analysis of B showed that 59% samples were low (20-24 mg kg^{-1}) and 41% were sufficient (25-60 mg kg^{-1}). The relationship between soil and plant nutrient status was highly significant with "R^2" value ranging from 0.57–0.81. It is concluded that micronutrients fertilization along with organic manures may be included in fertilization program. Further research may be conducted on wide range sampling strategy of study area.

Introduction

District Badin is a trading center for tomatoes in Sindh and contributes a lion share among the tomato cultivating zones i.e., Badin, Karachi, Mirpurkhas and Hyderabad. In Sindh, tomatoes are grown on an area of 8.7 thousand hectares from which 3.00 thousand hectares are grown under Badin district. While total area under tomato in Pakistan is 47.1 thousand hectares with average yield of 10.7 tons per hectare (Anon., 2007) which is very low as compared to other countries like Spain (63.55 tons ha^{-1}), the Netherland (146 tons ha^{-1}) and California (88.91 tons ha^{-1}) even within other provinces of Pakistan, Balochistan contributing the maximum (12.7 tons ha^{-1}) and Sindh with a minimum figure of 7.00 tons ha^{-1} (Anon., 2007).

Tomato requires both major and micronutrients for its proper plant growth (Sainju *et al*., 2003). Major nutrients i.e., nitrogen (N), phosphorus (P) and potassium (K) are supplied using chemical fertilizers which also contain S compounds and Ca and Mg stocks are generally adequate. In contrast, micronutrients (B, Cu, Fe, Mn, Zn and Mo) are normally not applied which leads to micronutrient deficiency disorders in many crops of Pakistan (Rashid & Rayn, 2004). In addition the cultivation of high yielding varieties with unbalanced fertilizer inputs, intensive cropping system, decreased use of manures and calcareous nature (>7.5) of soil increases the extent of micronutrient deficiencies (Cakmak, 1998; Anon., 1998; Tandon, 1995; Mortvedt *et al*., 1991). Micronutrient (Fe, Zn, Mn and Cu) availability can also reduce by the excess use of P levels in soil that are less harmful to tomato (Mortvedt *et al*., 1991; Sainju *et al*., 2003). Micronutrients apparently play an essential role in the enzyme activities of the plants. Deficiency of these nutrients can affect not only its yield (Patil *et al*., 2008) but also its nutrient content, taste (Hårdh & Takala, 1979) and post-harvest storage quality (Passam *et al*., 2007). Therefore rate and type of nutrients applied in the form of fertilizers should be adjusted each year after analyzing the nutrient contents of soil and plant samples.

A large number of soil analysis indicated that 50% of the soils were deficient in B, 21% in Fe and 57% in Zn in Punjab. Similarly in Khyber Pakhtoon Khwa 60% soil samples were deficient in B, 14% in Fe and 37% in Zn. Soil samples from Sindh, Baluchistan and AJK areas were also tested and were deficient in micronutrients (Anon., 2002). Much of the micronutrient research on calcareous soils of Pakistan is related to cotton (Rashid & Rafique, 2002), rapeseed (Rashid *et al*., 2002a), peanut (Rashid *et al*., 1997), wheat (Rashid *et al*., 2002b), potato (Anon., 1998) and orchards (Zia *et al*., 2006) with special reference to banana and apple. Micronutrient deficiencies not only reduce crop production but low Zn, Fe plant food can also adversely affect human health. Little work has been done on the micronutrient management of the tomato growing areas specially where plant analysis is taken under consideration. Analysis of soil and associated plant tissues can be a useful tool in identifying nutritional problems, leading towards better yield targets (Rashid, 2005). This study was therefore conducted to access the micronutrient availability of tomato growing areas of Sindh, Taluka Badin as a case study.

Materials and Methods

Site description: District Badin is located between 24^{o} 13' and 25^{o} 12' north latitude and 68^{o} 21' to 69^{o} 20' east longitude. The summer temperatures (25-45^{o}C) of district Badin favor the cultivation of tomato. The variety under cultivation was "Rooma" and the area under cultivation for

32 growers ranged from 4 to 7 acres. The soils in Left Bank Canal command areas are deep alluvial deposits suitable for irrigated agriculture. Phulali and Akram canals coming from Hyderabad irrigate this area. The soils of tomato growing areas of Taluka Badin are moderately calcareous, alkaline in reaction and clayey in texture.

Sampling: The soil samples of this study were collected from 32 major tomato-growing areas of cultivated fields of Taluka Badin in south of Sindh. Surface soils (each composite of three) were collected from 32 major growing areas of Taluka Badin. Three soil cores at the depth of 0-15 cm were collected from each grower and composited to form one sample. The soils were stored in polyethylene bags in the field, and kept cool till returning to the lab. Prior to analysis, soils were air-dried, roots and other recognizable plant material was removed, ground to pass through 2 mm sieve and homogenized by hand. The part of the plant chosen for analysis is usually the leaf, which is metabolically very active and whose composition is therefore a good guide to changes in the plant nutritional status. At the time of soil sampling, associated plant samples were also collected using the same sampling strategy as described for soil collection. Fifteen youngest fully matured leaves (3^{rd} leaf from top) at mid bloom (Jones *et al*., 1991) were randomly selected from each grower and composited to form one sample, washed with distilled water, oven dried at 68^oC and ground.

Physical and chemical analysis: Soil pH was determined by pH electrode in 1:2 soil/deionized water suspension, organic matter by potassium dichromate oxidation and soil texture by the Bouyoucos method (Jackson, 1962). The soils were extracted for Cu, Fe, Mn and Zn using Ammonium bicarbonate di-ethylene tri-amine penta acidic acid (AB-DTPA) method of Soltanpour & Schwab (1977) and the extracts were analysed by Atomic Absorption Spectrophotometer. Whereas soils were extracted by hot-water method for B as introduced by Berger & Truog (1939) and was measured calorimetrically using azomethine-H method of Bingham (1982). The plant samples were digested by wet oxidation method in 1:5 $HClO_4$:HNO_3 mixture and analyzed for Cu, Fe, Mn, Zn and B using atomic absorption spectrophotometer. We did not include the analyses of Mo and Cl because they are very rarely needed.

Results and Discussion

Fertilization practices of tomato growers: The information regarding fertilization practices followed by the tomato growers in Taluka Badin is presented in Table 1. The farmers of these areas are using only nitrogenous and phosphatic fertilizers in the form of urea and di-ammonium phosphate. Most of the farmers used adequate amounts of nitrogen, but they generally use inadequate quantity of phosphatic fertilizer when compared to the recommended dose of 100-100-60 kg N-P_2O_5-K_2O ha^{-1} (Ahmad & Rashid 2003). In the surveyed area, 44% growers used full recommended N, 25% each used ½ and ¾ of the recommended dose and 6% were above the recommended doze. Similarly, 75% growers used 1/4 of the recommended dose, 19% used ½ of the recommended and only 6% were close (about $3/4^{th}$) to the recommended dose. There is no awareness of using potash or micronutrient fertilizers.

Table 1. Fertilization practices of tomato growers in Taluka Badin, Sindh.

Site No.	Fertilizer used N + P2O5 (kg ha-1)	Site No.	Fertilizer used N + P2O5 (kg ha-1)
1	55 + 23	17	110 + 46
2	101 + 23	18	110 + 46
3	78 + 23	19	78 + 23
4	55 + 23	20	119 + 69
5	78 + 23	21	101 + 23
6	101 + 23	22	78 + 23
7	124 + 23	23	55 + 23
8	110 + 46	24	78 + 23
9	55 + 23	25	55 + 23
10	101 + 23	26	110 + 46
11	124 + 23	27	55 + 23
12	110 + 46	28	55 + 23
13	110 + 46	29	78 + 23
14	78 + 23	30	119 + 69
15	101 + 23	31	101 + 23
16	55 + 23	32	78 + 23

Summary characteristics of soils: Summary characteristics of soils are presented in Table 2. Majority of the soils (81%) were clayey in texture followed by sandy clay (13%) and silty clay (6%). Electrical conductivity values showed that 80% soils were non-saline and 20% were slightly saline (0.62-3.13 dS m^{-1}). The soils were alkaline (pH 8.08-8.62) and poor in organic matter (0.41-0.84%).

Micronutrient contents of soils revealed wide spread deficiencies of B and Zn in tomato fields of Taluka Badin (Table 3). Copper contents of surface soils ranged from 5.0-6.9 mg kg^{-1} with mean value of 5.8 mg kg^{-1}, Fe from 24-79 mg kg^{-1} with average value of 54.8 mg kg^{-1}, Mn from 8.8-22.3 mg kg^{-1} with average value of 12.9 mg kg^{-1}, Zn from 0.51-2.1 mg kg^{-1} with average value of 0.87 mg kg^{-1} and B from 0.02-0.6 mg kg^{-1} with average value of 0.29 mg kg^{-1}. The AB-DTPA extractable soil nutrients (Cu, Fe, Mn and Zn) were categorized according to the critical values suggested by Soltanpour & Schwab (1977) and hot-water B by Johnson & Fixen (1990). The data revealed that all the soils were adequate in Cu (> 0.5 mg kg^{-1}), Fe (> 4 mg kg^{-1}), and Mn (>1.8 mg kg^{-1}) .However, 66% soils were low (< 1.0 mg kg^{-1}), 28% marginal (1.0-1.5 mg kg^{-1}), and only 6% were adequate (> 1.5 mg kg^{-1}) in soil Zn. As for B, 91% samples were low (< 0.5 mg kg^{-1}) and only 9% were adequate (>1.0 mg kg^{-1}) (Table 3).

Table 2. Summary characteristics of soils sampled from Taluka Badin, Sindh.

Soil property	Range	Mean ± SD
pH*	8.08-8.62	8.30 ± 0.1
Electrical conductivity (dS m^{-1})*	0.62-3.13	1.57 ± 0.58
Organic matter (%)	0.41-0.84	0.68 ± 0.16
Sand (%)	1.0-30.5	6.00 ± 8.1
Silt (%)	27.5-49.50	39.70 ± 7.4
Clay (%)	39.0-65.00	54.90 ± 7.8

* 1:2 soil-water extract

As generally observed in many studies conducted in Sindh and elsewhere (Memon *et al*., 1988-1989; Anon., 1998; Kaya *et al*., 2001; Rashid *et al*., 2006 and Dursun *et al*., 2010), the soils were not deficient in Cu, Fe and Mn but B and Zn. Boron being a mobile element in soil can leach down the soil profile and normally its availability is low in alkaline calcareous soils (Rashid & Ryan, 2004). Memon *et al*., (1988-1989) also observed that 44% soils of District Badin were deficient in Zn. Our results with regard to B and Zn deficiency in soil are further in agreement with the results of Zia *et al*., (2006) who observed B and Zn deficiencies in orchard soils of Balochistan (64%, 43%) and Sindh (94%, 90%). Similarly, 60% orchard soils were reported to be deficient in Punjab.

Table 3. Micronutrient contents in tomato leaves and associated soils collected from Taluka Badin, Sindh.

Nutrient	Range	Mean ± SD	Low	Adequate	High
Soil micronutrient contents					
B	0.02-0.60	0.29 ± 0.14	< 0.5 29(91)	0.5-1.0 3(9)	>1.0 0(0)
Cu	5.00-6.92	5.77 ± 0.54	<0.5 0(0)	- 0(0)	>0.5 32(100)
Fe	24.00-79.00	54.81 ± 12.89	0-2.0 0(0)	1-4.0 0(0)	>4.0 32(100)
Mn	8.76-22.32	12.90 ± 2.79	<1.8 0(0)	- 0(0)	>1.8 32(100)
Zn	0.51-2.13	0.87 ± 0.38	<1.0 21(66)	1-1.5 9(28)	>1.5 2(6)
Plant micronutrient contents					
B	10.00-39.00	23.78 ± 8.90	20-24 19(59)	25-60 13(41)	>60 0(0)
Cu	10.00-27.30	19.00 ± 3.52	3-4 (0)	5-20 26(81)	>20 6(19)
Fe	319.0-1177.0	597.63 ± 255.93	30-39 0(0)	40-200 0(0)	>200 32(100)
Mn	39.00-85.65	56.47 ± 13.50	30-39 2(6)	40-250 30(94)	>250 0(0)
Zn	13.00-191.40	55.95 ± 41.03	18-19 8(25)	20-50 7(22)	>50 17(53)

Note: The values underlined are the critical limits of the given nutrient
The values outside and in parenthesis denote number and percent samples respectively

Micronutrient contents of tomato plants: Boron concentration in tomato leaves ranged from 10 to 39 mg kg^{-1} with mean value of 23.78 mg kg^{-1}, Cu from 10 to 27 mg kg^{-1} with mean value of 19 mg kg^{-1}, Fe from 319 to 1177 mg kg^{-1} with mean value of 598 mg kg^{-1}, Mn from 39 to 86 mg kg^{-1} with mean value of 56 mg kg^{-1} and Zn from 13 to 191 mg kg^{-1} with mean values of 56 mg kg^{-1} (Table 3). The plant samples were categorized according to the critical values suggested by Jones *et al*., (1991). All the plant samples were high in Fe (> 200 mg kg^{-1}), whereas Cu was high (> 20 mg kg^{-1}) in 19% samples and sufficient (5-20 mg kg^{-1}) in 81% samples. Manganese was sufficient (40-250 mg kg^{-1}) in 94% samples and low (30-39 mg kg^{-1}) in 6% samples. The data further showed that 53% samples were high (>50 mg kg^{-1}), 22% samples sufficient (20-50 mg kg^{-1}) and 25% low (18-19 mg kg^{-1}) in Zn. In case of B, 59% samples were low (20-24 mg kg^{-1}) and 41% were in sufficient range (25-60 mg kg^{-1}) in B (Table 3). These results are in line with the studies conducted by Rashid & Qayyum (1991). They recognized micronutrient deficiencies in wide range of soils, crops and fruits in Khyber Pakhtoon Khwa, Punjab, Balochistan, Sindh and Azad Jammu and Kashmir. A wide spread deficiency of Zn and B in rainfed soils and crops of Pothowar plateau was also established (Rashid & Qayyum, 1991). The results are further supported by Kaya *et al*., (2001), Nasrin (2002), Gezgin & Hamurcu (2006) and Angin *et al*., (2008).

Relationship between soil characteristics and micronutrient status of soils: The data regarding the relationship of soil properties with micronutrient status of soils are expressed in terms of “coefficient of correlation, r” as given in Table 4. These data indicate that there was essentially no relationship of pH and EC values with any of the micronutrients B, Cu, Fe, Mn and Zn. It was also observed that there was significant negative relationship (r = -34) between silt and Fe contents of soils while the relationship between soil clay and Zn contents was positive and significant with "r" value equal to 0.38. Further, it was noted that "r" values were positive for the relationship of organic matter contents with any of the micronutrients under study. Results observed by Wei *et al*., (2006) indicate that soil organic matter exerts a significant and direct effect on the availability of Zn, Mn, and Fe. Positive and significant relations were further supported by Golia *et al*., (2008) in case of Zn.

Table 4. Coefficient of correlation (r values) between surface soil characteristics and soil micronutrient contents.

Soil characteristic	B	Cu	Fe	Mn	Zn
	Soil micronutrient contents (mg kg^{-1})				
pH*	0.05 NS	-	0.08 NS	-0.17 NS	-0.12 NS
EC (dS m^{-1})*	0.16 NS	-0.05 NS	0.07 NS	-0.09 NS	-0.01 NS
Organic matter (%)	0.14 NS	0.28 NS	0.13 NS	0.22 NS	0.15 NS
Sand (%)	0.07 NS	0.14 NS	0.06 NS	0.01 NS	-0.26 NS
Silt (%)	-0.19 NS	0.02 NS	-0.34 *	-0.06 NS	-0.15 NS
Clay (%)	0.16 NS	-0.16 NS	0.19 NS	0.04 NS	0.38*

NS –Non significant, * significant at 5% level

Relationship between micronutrient contents of soil and associated plant index tissue: The micronutrient contents of plant index tissue were regressed against soil content of micronutrients to determine the nature of their relationship as given in Fig. 1. The relationship was linear, positive and significant ($p<0.01$) for all the 5 micronutrients B, Cu, Fe, Mn, and Zn and described by the following equations:

Boron: $Y = 39.93x + 12.37$, $R^2 = 0.37$ (Fig. 1a)
Copper: $Y = 5.35x – 11.83$, $R^2 = 0.67$ (Fig. 1b)
Iron: $Y = 15.04x – 227$, $R^2 = 0.57$ (Fig. 1c)
Manganese: $Y = 3.42x + 12.32$, $R^2 = 0.50$ (Fig. 1d)
Zinc: $Y = 98.35x – 30.01$, $R^2 = 0.83$ (Fig. 1e)

Similar findings on soil and plant relationship are reported by many researchers. Positive relations were observed for Zn by Kaya & Higgs (2001) and Golia *et al*., (2008) (r = 0.77-0.85) in tomato, by Rafique *et al*., (2006) in wheat (r = 0.52); for Cu in tomato by Kaplan (1999) and Golia *et al*., (2008) (r = 0.59-0.69). In case of B, Dursun *et al*., (2010) found a curvilinear relationship ($y = –1.87x^2 + 15.73x + 3.36$, $R^2 = 0.95$) between tomato leaf tissue contents and applied B ranging from 0.5 to 4 kg ha^{-1}.

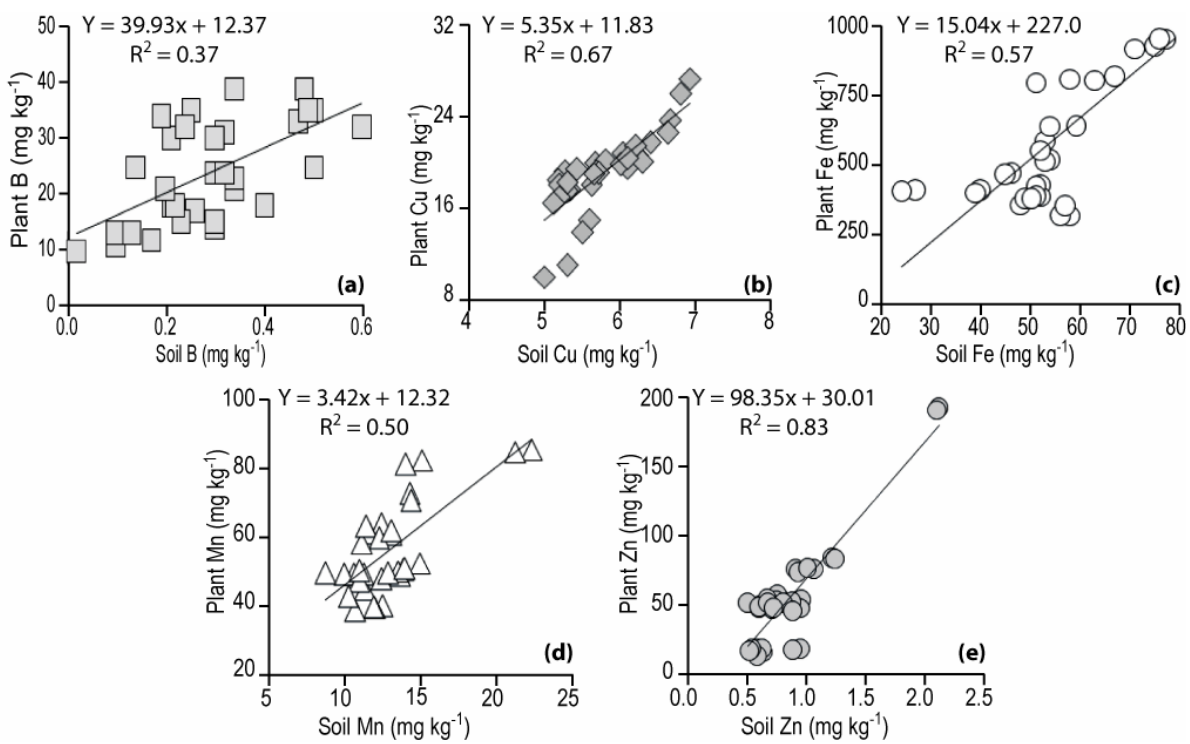

Fig. 1. Relationship between soil (hot water extractable B and AB-DTPA extractable Cu, Fe, Mn and Zn) and plant ($HClO_4$:HNO_3 digested) micronutrients of tomato growing fields: (a) B (b) Cu (c) Fe (d) Mn an

Conclusions

It is concluded from the soil testing and plant analysis data that tomato fields in Taluka Badin were adequate in supply of Cu, Fe and Mn. However Zn and B deficiencies existed in soils and associated plant tissue. These results indicate the need for further studies to determine the effect of soil and foliar applications of Zn and B for obtaining optimum yields. In addition to this, application of organic matter may help increase availability of micronutrients, in addition to supplementing major nutrient supply to tomato. Further research on wide range of tomato growing regions of Sindh is desirable to obtain holistic view of tomato nutrition.

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