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STATUS OF MICRONUTRIENTS IN INTENSIVELY CULTIVATED POTATO GROWING SOILS OF PUNJAB

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ABSTRACT: Available Zn, Fe, Mn, Cu and B were studied in the intensively cultivated soils (potato based and non-potato based cropping systems) of Jalandhar district of Punjab. A large variation was observed in DTPA extractable zinc ranging from 0.20 to 9.76 ppm (mean 3.20), Fe ranging from 1.61 to 180.9 ppm (mean 44.9), Cu ranging from 0.4 to 4.55 ppm (mean 2.18) ppm and Mn ranging from 1.74 to 141.0 ppm (mean 36.9). Majority of the soils contained high to very high contents of micronutrients cations. Based on critical limits of 0.55, 4.5, 0.3 and 1.0 mg/kg soil for Zn, Fe, Cu and Mn, respectively, out of 100 samples only one was found deficient in zinc and eight were marginally deficient in Fe. Hot water extractable B was less than 0.5 ppm in all the soils. As per the soil fertility evaluation and fertilizer recommendations in the state of Punjab, 49% samples were low and 49 % were medium in soil organic carbon. Micronutrient content (Zn, Fe, Cu and Mn) in soils of potato based cropping system was higher than soils of non-potato based cropping system. Available Fe, Mn and Zn contents were 4.72, 1.46 and 1.52 times higher in soils where paddy was a component crop of the cropping system compared to the soils where it was not being grown.

KEY WORDS: Cropping systems, micronutrients, potato and paddy, Punjab

INTRODUCTION

Micronutrients play many important and complex roles in promoting strong plant growth. Besides increasing yield and improving the harvest quality they also play an important role in improving plant health. It is reported that 49 per cent of soils in India are potentially deficient in Zn, 12 per cent in Fe, 5 per cent in Mn, 3 per cent in Cu, 33 per cent in B (Singh, 2008) and the extent of deficiency in Punjab soils for Zn, Fe, Mn and Cu was reported as 49, 17, 3 and 2%, respectively (Nayyar *et al.*, 1990).

Due to availability of subsidized fertilizers and lack of adoption of soil test based nutrient application by the farmers, excessive fertilizer application of both macro and micronutrients has become a common farmers' practice in certain areas of the country. Over-fertilization by farmers to achieve higher yields does not always benefit as the nutrient interactions in soil also affect the availability of many nutrients. Besides, it leads to nutrient imbalance in the soil, low nutrient use efficiency and environmental pollution (Giglitti *et al.*, 1996 and Gibbs *et al.*, 2006). Imbalanced use of nutrients has led to build up of some of the micronutrients in the soil whereas some of the micronutrients have depleted in the soil. It is evident from the fact that yield at farmers' fields is lower than the yield obtained in experimental fields. Good nutrient management practices can narrow down this yield gap (Chaudhary and Narwal, 2005; Delibacak *et al.*, 2009). Knowledge of the nutrient supplying capacity of the soil is pre-requisite to develop good

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nutrient management practices in order to minimize such yield gap without degrading the environment. Many workers have also recommended that nutrient supplying capacity of soil must be taken into consideration when developing fertilizer recommendations (Kutman *et al.*, 2010; Lair *et al.,* 2007). Due to high nutrient demand, and intensive cultivation and little recycling of crop residues, the soils of Punjab are assumed to be deficient in micronutrients particularly zinc. However, this has been thought without any real-time data analysis on a regional scale. Since changes in micronutrient content are expected as a result of addition of manures and fertilizers over the years, the present study was undertaken to know the status and spatial variability of micronutrients in intensively cultivated soils under potato and non potato based cropping systems.

MATERIALS AND METHODS

One hundred surface soil samples (0-15 cm) were collected from intensively cultivated potato (n=50) and non potato based cropping systems (n=50) before sowing/planting of rabi crops during the year 2015. The study area comprised of villages namely, Chitti, Kang Sabbu, Lallian Kalan, Lallian Khurd and Lambra between 30.13 to 31.16°N and 75.13 to 75.32°E east in Jalandhar district of Punjab. The major cropping systems included maize-potato-wheat, paddy-potato-bajra/maize, paddy- bajra/ maize-wheat, maize/bajra/ paddy- wheat. Soil samples were analysed for pH (1:2.5 soil : water suspension) and electrical conductivity (1: 2 soil : water supernatant), soil organic carbon (Walkley and Black method 1934). Soil texture was determined by international pipette method and the soils were sandy loam in texture. Available Zn, Fe, Mn, and Cu were extracted by DTPA (Lindsay and Norvell, 1978) and measured by atomic absorption spectrophotometry (AAS). Hot water soluble B was determined by colorimerically using azomethine-H. In order to study the relationship between soil properties and soil available micronutrients, correlation analysis was carried out. Information regarding fertilizer usage of macro as well as micronutrients and average potato crop yield was recorded from each farmer.

RESULTS AND DISCUSSION

Soil properties and micronutrients status

Range and mean values of soil properties (texture, organic carbon, pH and EC) are given in **Table 1**. The soils under investigation belonged to sandy or sandy loam texture and were near neutral to alkaline in reaction (pH 6.65 to 7.99). Electrical conductivity ranged from 0.04 to 0.19 dS/m. Organic carbon ranged from 1.3 to 13.5 (mean 4.3 g kg^{-1}) g kg^{-1}. In seventy six percent of the samples organic carbon content was

Table 1. Range and mean of important soil properties.

Statistics	Sand (%)	Silt (%)	Clay (%)	EC (dS/m)	pH (1:25)	OC (%)
Mean	79.75	21.58	6.69	0.08	7.33	0.43
Standard Error	0.50	0.24	0.28	0.003	0.03	0.02
Standard Deviation	4.98	2.37	2.83	0.03	0.30	0.18
Sample Variance	24.81	5.62	7.98	0.001	0.09	0.03
Minimum	64.67	16.75	3.05	0.03	6.54	0.13
Maximum	92.30	28.02	14.50	0.20	7.99	1.35
Confidence level (95.0%)	0.99	0.47	0.56	0.01	0.06	0.04

<0.5%. As per the soil fertility evaluation and fertilizer recommendations in the state, soils containing less than 4.0 g kg^{-1} organic carbon are classified as low, 4.0–7.5 g kg^{-1} medium and greater than 7.5 g kg^{-1} as high in fertility. Accordingly 49% samples were low and 49% were medium in organic carbon. Use of very low amount of organic manures, green manures and imbalanced application of chemical fertilizers were the main reasons for poor organic carbon. Little recycling of crop residues was another reason for low organic carbon content since 82 percent of the rice straw and 17% of the wheat straw is burnt in the fields and the rest is removed from the field for other purposes in Punjab (Beri *et al.*, 2003). The practice of burning of crop residues is common in this region. Moreover high temperature during summer (March to June) prevailing in the area may also be responsible for the rapid decomposition of organic matter, thus resulting in low organic C content in these soils. Electrical conductivity ranged from 0.03 to 0.2 dS/m (mean 0.08). On the basis of EC limit proposed by Muhr *et al.* (1965), most of the soils under investigation fell in category of normal soils.

Micronutrient contents particularly of Fe and Mn exhibited a wide variation (**Table 2**). Micro nutrient availability in soil is influenced by soil properties, cropping and fertilization practices (Bogdanovic *et al.*, 1999; Cakmak 2010) such as manure application, fertilizer application or fungicide use. DTPA extractable zinc ranged from 0.20 to 9.76 ppm (mean 3.20), Fe ranged from 1.61 to 180.9 ppm (mean 44.9), Cu ranged from 0.4 to 4.55 ppm (mean 2.18) ppm and Mn ranged from 1.74 to 141.0 ppm (mean 36.9) (**Table 2.**). Nayyar *et al.* (1990) have also reported a large variation in micronutrient content in Punjab. Based on critical limits of 0.55, 4.5, 0.3 and 1.0 mg/soil for Zn, Fe, Cu and Mn, respectively, only one sample was found deficient in zinc and eight were marginally deficient in Fe. Copper and Mn contents were above critical limits in all the samples. Considering 3.5 ppm as critical limit for DTPA-extractable Mn and 0.60 ppm for Zn (Nayyar *et al.*, 1985) for the Punjab soils, 10% samples were found deficient in available manganese and only three percent were deficient in available Zn in our study whereas the extent of deficiency in Punjab soils for Zn, Fe, Mn and Cu was reported as 49, 17, 3 and 2%, respectively (Nayyar *et al.*, 1990). Use of micronutrient containing pesticides over the years and addition of micronutrient containing fertilizers could be a reason for high content of these nutrients in soil. Fungicide usage has been found to influence accumulation of copper in soil (Fan *et al.*, 2011). Since there was large variation in micronutrient nutrient status, to avoid wasteful expenditure, their status should be monitored regularly and doses should be adjusted accordingly. Thirty eight percent of potato growers, on an average, applied 10 kg zinc sulphate/ha to potato crop despite

Table 2. Range and mean of available micronutrients in soils.

Statistics	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Boron (ppm)
Mean	3.20	44.90	2.18	36.93	0.11
Standard Error	0.20	5.16	0.09	3.48	0.01
Standard deviation	2.04	51.63	0.89	34.77	0.06
Minimum	0.20	1.61	0.40	1.74	0.01
Maximum	9.76	180.85	4.55	140.99	0.42
Confidence level (95.0%)	0.40	10.24	0.18	6.90	0.01

high available zinc content ranging from 1.30 to 9.76 ppm (mean value 3.86 ppm) without any yield advantage compared to those who did not add Zn. Hence, there is an urgent need to educate the farmers for adopting soil test based fertilizer use. Hot water soluble B content ranged from 0.01 to 0.42 ppm (mean 0.11). Considering critical limit of 0.5 ppm for available boron in soil, 100% samples were found deficient in this element. However, based on critical limit of 0.1 ppm for hot water soluble boron in soil for potatoes (Berger 1949) 52% samples were found deficient in this element. Since it is recommended to treat the potato seed with 3% boric acid for the control of seed borne diseases, low levels of hot water extractable boron in soil may not affect the potato yield. However, this is an alarming situation for other crops being grown in this region as none of the farmers reported use of boron containing fertilizers.

Relationship between micronutrients status and soil properties

Available Zn (r = 0.2211), Fe (r = 0.2987) and Mn (r = 0.3260) were positively and significantly but weakly correlated with organic carbon content (**Table 3**). Soil pH exhibited significant negative correlation (r = -0.3700) with zinc but with Fe it was weak (r = -0.1975). Soil pH affects the available micronutrient content in the soil and as the soil pH increases the availability of micronutrients decreases. Sidhu and Sharma (2010) also reported that the available micronutrients (Zn, Cu, Mn and Fe) increased with increase in organic carbon and decreased with increase in sand content, pH, and calcium carbonate. Sharma *et al.* (2004) investigated that the total content of micronutrients (Fe, Cu, Zn, Mn) increased with an increase in clay and silt and CEC, whereas DTPA-extractable micronutrient increased with an increase in organic carbon content and CEC, and decreased with increasing pH, sand and calcium carbonate content. Boron was positively correlated with soil clay content (r = 0.2468). Moafpouryan and Shukla (2004) observed that the water soluble, non-specifically adsorbed and specifically adsorbed boron were significantly and positively correlated with organic carbon, CEC and clay content. Mathur *et al.* (2006) reported that the DTPA-extractable zinc was significantly and negatively correlated with pH (r = -0.383), and positively correlated with organic carbon (r = 0.738), and clay content (r = 0.385). In general, the available micronutrient cations in soils exhibited weak correlation with soil organic carbon and soil pH which could be due to their high contents in soil and narrow range of organic carbon and soil pH amongst majority of the samples in the present study.

Table 3. Correlation coefficients between available micronutrients and important soil properties.

	Zn	Fe	Cu	Mn	B
OC (%)	0.2211*	0.2987*	0.3260*	-0.0113	0.0763
pH	-0.3700*	-0.1975	0.2180*	0.1817	-0.1097
Silt (%)	-0.0451	0.2055*	0.2746*	0.2512*	0.0674
Clay (%)	0.0043	-0.0980	-0.2794*	0.1521	0.2468*

*significant at p=0.05 level of significance

Cropping systems and micronutrients status

In potato growing soils micronutrient content except B was very high. Mean content of Zn, Fe, Cu and Mn was 3.61, 52.54, 2.10 and 35.05 ppm, respectively indicating their excessive application. Based on the critical limits of DTPA-extractable Zn, Fe and Cu in alluvial soils of Jalandhar (0.75, 6.6 and 0.32 ppm, respectively) none of the potato growing fields irrespective of cropping system were deficient in Zn and Cu and only six fields (12%) were deficient in Fe whereas 100% soils were deficient in boron (<0.5 ppm B).

Micronutrient content in soils of potato based cropping system was higher than soils of non-potato based cropping system (**Fig. 1**). Use of micronutrient containing fungicides could be another reason for higher Zn, Cu and Mn content in potato based cropping system. Further, higher contents of these micronutrient cations were found invariably in fields where paddy was one of the component crop (**Fig. 2 and 3**). Considering 3.5 ppm DTPA-extractable Mn as the critical limit (Nayyar *et al.*, 1985) one field out of eighteen was deficient in Mn where paddy was a component crop of the cropping system whereas six out of thirty two fields were found deficient where paddy was not grown. Available Fe content was 4.72 times higher in paddy based cropping system. High

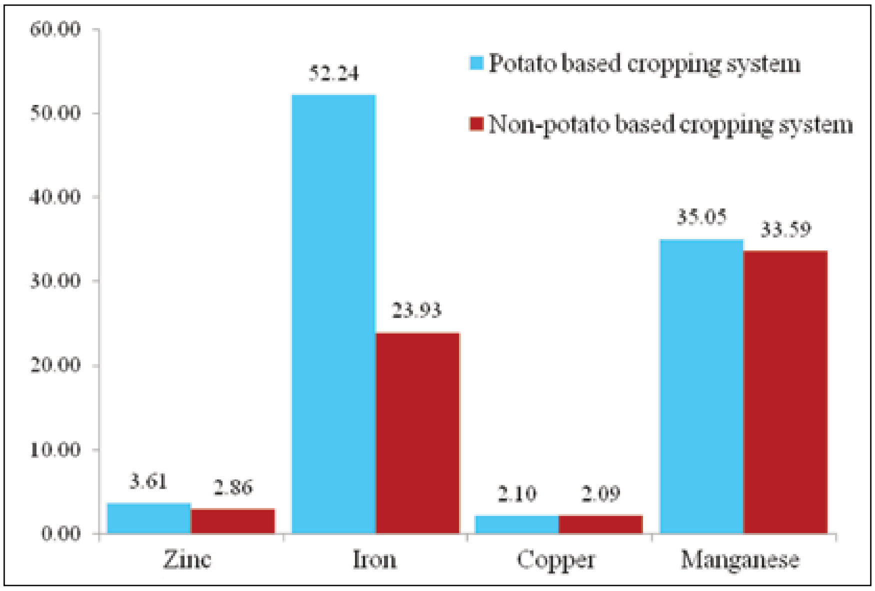

Fig. 1. Available micronutrient content in potato and non- potato based cropping system.

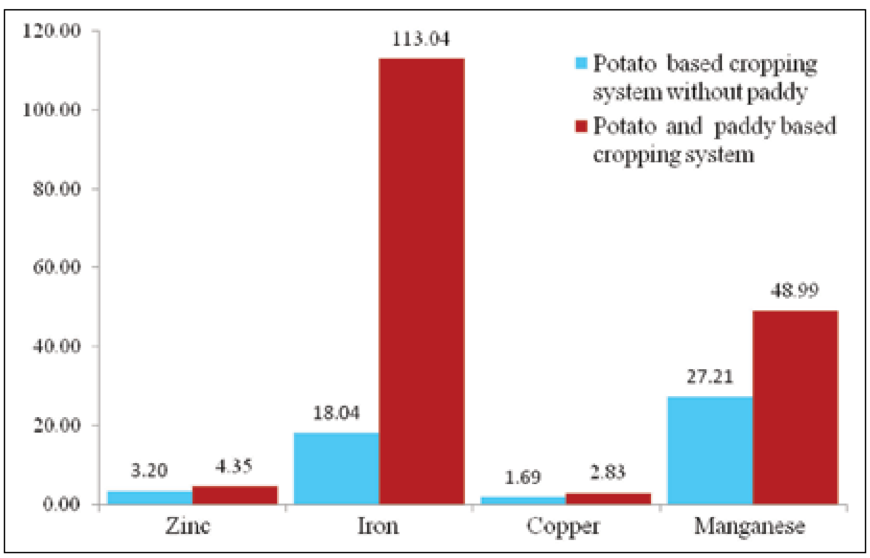

Fig. 2. Available micronutrient content (ppm) in potato based cropping system with and without paddy.

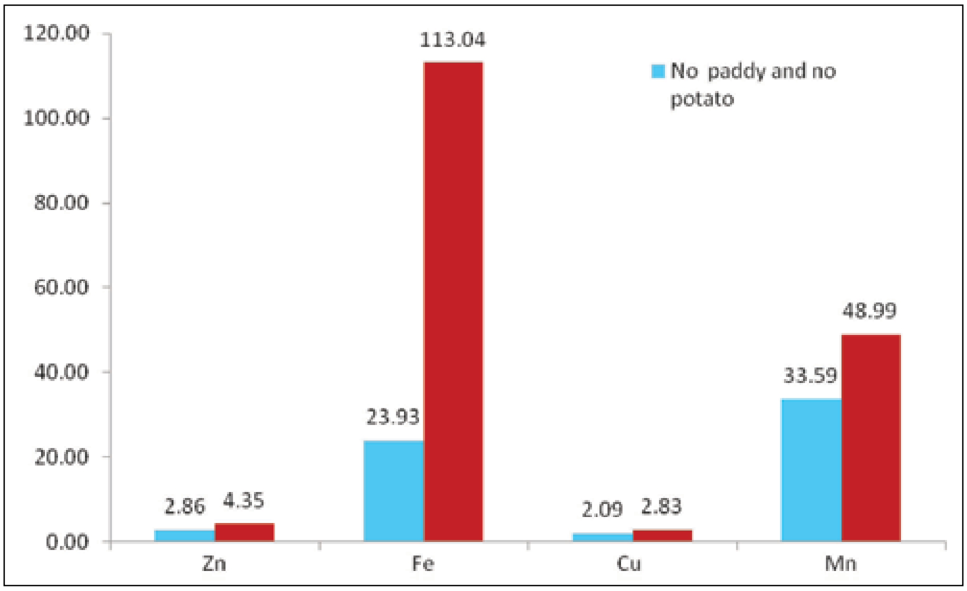

Fig. 3. Available micronutrient content (ppm) in different cropping systems with potato based. cropping system

available Fe content in paddy based cropping system could be due to the high sensitivity of Fe to electro-chemical changes in soils and increased availability of decomposable organic materials such as potato haulms or crop residues from preceding crops (Sadana and Nayyar 2000).

CONCLUSIONS

Majority of the soils in Punjab had optimum to very high contents of DTPA extractable micronutrient cations (Zn, Fe, Cu and Mn) and 100% soils were deficient in available boron having hot water extractable boron <0.5 ppm. Low levels of boron in soil indicates an alarming situation for different crops being grown in this region as none of the farmers reported specific use of boron containing fertilizers. Since there was large variation in nutrient status and micronutrient status is influenced farming practices including fungicide usage their status should be monitored regularly and doses should be adjusted accordingly. There is a need to educate the farmers to apply the nutrients on soil test basis to avoid wasteful expenditure and undesirable nutrient interactions.

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