Original Research Article

Influence of Nutrient Management Practices on DTPA Soil Micronutrients and its Relation with Soil pH and Cation Exchange Capacity in Pearlmillet (*Pennisetum glaucum* L.) Cultivated Soils of Western India

Abstract

A field experiment was conducted during *kharif*, 2019 at Anand Agricultural University, Anand, Gujarat, India. The effect of nutrient management practices on soil pH, cation exchange capacity, DTPA micronutrient and their inter relationship were studied. The result of present study showed that relationship between available micronutrients and soil pH was significantly and negatively correlated for DPTA Fe, Mn and Zn. In case of DTPA Cu and soil pH relationship was positively correlated. The highest R^2 value for the relationship between DTPA micronutrients and soil pH was for the available Fe (0 79). The relationship between available micronutrients and cation exchange capacity of soil was reverse of soil pH. Available Fe, Mn and Zn were positively correlated with cation exchange capacity and reverse for DTPA Cu. The lowest R^2 value for relationship between DTPA micronutrients and soil cation exchange capacity was for DTPA Cu (0.008).

Keywords: Cation exchange capacity, Correlation, DTPA Micronutrients and Soil pH

Introduction

Nutrient availability from manure has been recognized in crop cultivation for ages. Manure was the major source of nutrients for crop production prior to the advent of chemical fertilizers. There has recently been a resurgence of interest in the utilization of farmyard manure. Concerns about sustaining sustainable agricultural output while safeguarding the environment are said to be driving this interest. Integrated nutrient management is the finest technique for greater resource usage and crop production at a lower cost. In this method, all viable sources of plant nutrients are used depending on cost, and the crop's nutritional balance is supplemented with chemical fertilizers. Organic manures such as animal dung manure (791.6 mt), crop residues (603.5 mt), rural compost (148.3 mt), city compost (12.2 mt), green manure (4.50 m ha), and biofertilizer (0.41 mt) are readily available in India (Bhattacharya and Chakraborthy, 2005), and these could be a good substitute for chemical fertilizers in maintaining the soil's physico-chemical and The use of organic manures boosts nutritional content and absorption (Vidyavathi *et al.*, 2012). Soil is the earth's top layer of loose material, which provides the primary basis for natural flora and other living forms on our planet. Soil fertility is one of the most critical elements that affects crop development and output. Micronutrients are essential for sustaining soil fertility and crop yield. Micronutrients are required in lesser amounts than macronutrients; yet, even if the macronutrients are balanced and high yielding varieties are cultivated, a lack of supply will prevent optimal yields (Yadav, 2011). The acidity and alkalinity of a soil solution are measured by its pH. The hydrogen ion concentration in soil is referred to as pH. The pH scale is not linear, but rather logarithmic. Because of its effect on the availability of vital plant nutrients and the concentration of components poisonous to plants, soil pH can have an impact on plant development (Brady and Weil, 2002). Within a pH range of 4 to 6, the majority of micronutrients such as Cu, Fe, Mn, and Zn are more readily accessible. Organic matter, during its decomposition liberates a number of organic acids, lowers the soil pH and increases the intensity of reduction in soils (Dhaliwal *et al.*, 2019).

Plants get the majority of their nutrients from the soil. It is well understood that optimal plant growth and crop yield are influenced not only by the total amount of nutrients present in the soil at any given time, but also by their availability, which is influenced by physico-chemical properties such as soil texture, organic carbon and calcium carbonate, cation exchange capacity, pH, and electrical conductivity (Bell and Dell, 2008). Gupta (1968) found that soil pH, specific surface area, and clay organic carbon content all affected water soluble boron in soil. Therefore, understanding the chemistry of interrelated soil properties is required for sustainable soil management.

Materials and methods

A field experiment was conducted during *kharif* season 2019 at the Collage Agronomy Farm of Anand Agricultural University, Anand, Gujarat, India. The experimental site is located at 220 35′ N and 720 55′ E with an elevation of 45.1 meters above mean sea level. Soils in the experimental field belong to goradu soil series typical of the Inceptisols (Typic Ustochrept). The soil properties and treatment details of the experimental site are given in table 1 and table 2, respectively.

Table 1: Initial soil properties of the experimental site

Soil characteristics	Content
Texture	Loamy sand
pH	8.16
EC	0.23 (dSm^{-1})
Cation exchange capacity	11.25 [C mol (P^{+}) kg^{-1}]
Organic carbon	0.28%
Available nitrogen	188 kg ha^{-1}
Available phosphorus	53.7 kg ha^{-1}
Available potassium	537.6 kg ha^{-1}
DTPA Fe	5.20 (mg kg^{-1})
DTPA Mn	6.39 (mg kg^{-1})
DTPA Zn	1.20 (mg kg^{-1})
DTPA Cu	1.59 (mg kg^{-1})

Table 2. Treatment details of experiment

The recommended dose of fertilizer was 120-60-0 kg ha^{-1} N, P_2O_5, K_2O. The application of Bio NP consortia (liquid bio-fertilizer contains *Azotobacter* + PSB) was 5 ml of inoculant in 1 liter of water for 15 minutes as seedling treatment before transplanting of pearlmillet and one liter ha^{-1} at 30 days after transplanting of pearlmillet as soil drenching.

Treatments	Treatment details
T1	100% RDF (control)
T2	100 % RDF + 10 t FYM ha^{-1}
T3	100 % RDF + 10 t FYM ha^{-1} + Bio NP Consortia
T4	100 % RDF + 15 t FYM ha^{-1}
T5	100 % RDF + 15 t FYM ha^{-1} + Bio NP Consortia
T6	75% RDF + 10 t FYM ha^{-1}
T7	75% RDF + 10 t FYM ha^{-1} + Bio NP Consortia
T8	75% RDF + 15 t FYM ha^{-1}
T9	75% RDF + 15 t FYM ha^{-1} + Bio NP Consortia
T10	FYM ha-1 + 5.0 t Vermicompost ha^{-1} + Bio NP Consortia

Laboratory Analysis

The collected samples were air-dried and ground to pass through a 2 mm sieve. The samples were stored in polythene lined cotton bags for further analysis in the laboratory for the determination of different properties at ICAR-Micronutrient Research Scheme, Anand Agricultural University, Anand, India. The methods adopted for chemical determinations are listed in the table 3.

Table 3: Methods used for laboratory analysis

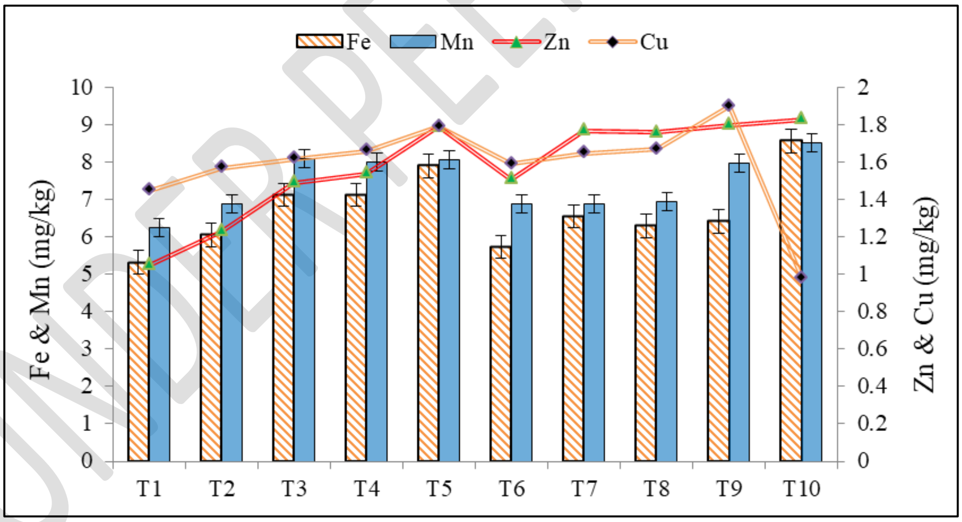
Parameters	**Methods**
Soil pH	Potentiometric 1:2 (Jackson, 1973)
CEC	1*N* NH_4OAc pH 7.0 Method (Jackson, 1973)
Micronutrients	
Available Fe	
Available Mn	DTPA (Lindsay and Norvell, 1978)
Available Zn	
Available Cu	

Result and Discussion

Effect of nutrient management practices on DTPA micronutrients in soil

The DTPA extractable micronutrient cations (Fe, Mn, Zn, and Cu) in soil as influenced by direct effect of organic manures, inorganic fertilizers along with bio-fertilizers are presented in figure 1. The results revealed that addition of FYM, vermicompost and bio-fertilizer in combination of chemical fertilizer or alone significantly affected the DTPA extractable Fe, Mn, Zn and Cu in the soil. It was observed that available Fe (8.58 mg kg^{-1}), Mn (8.53 mg kg^{-1}) and Zn (1.83 mg kg^{-1}) were found significantly higher due application of 15 t FYM ha^{-1} + 5.0 t Vermicompost ha^{-1} + Bio NP Consortia (T10) whereas DTPA extractable Cu noticed significantly higher under T9. The DTPA extractable Fe was higher than the critical limit of 4.5 mg kg^{-1} in all the treatments. Further, the data indicated that application of 15 t FYM ha^{-1} + 5.0 t Vermicompost ha^{-1} + Bio NP Consortia (8.58 mg kg^{-1}) remained at par with T5 (7.90 mg kg^{-1}). In case of DTPA Mn T10 (8.53 mg kg^{-1}) was at par with T3 (8.10 mg kg^{-1}), T4 (8.02 mg kg^{-1}), T5 (8.07 mg kg^{-1}) and T9 (7.98 mg kg^{-1}). DTPA extractable Mn was also higher than the critical limit (2.0 mg kg^{-1}) in all the treatments. The DTPA-Zn content of soil was significantly higher under T10 (1.83 mg kg^{-1}) over control and it was found at par with T4 (1.54 mg kg^{-1}), T5 (1.79 mg kg^{-1}), T7 (1.77 mg kg^{-1}), T8 (1.76 mg kg^{-1}) and T9 (1.80 mg kg^{-1}). The available Zn status in the soil remained above the critical value of 0.5 mg kg^{-1} in all the treatments. The DTPA-Cu was also significantly influenced due to T9 (1.90 mg kg^{-1}) which was at par with T4 (1.66 mg kg^{-1}), T5 (1.79 mg kg^{-1}), T7 (1.65 mg kg^{-1}) and T8 (1.67 mg kg^{-1}). Many cultivated soils are abundant in Fe, on an average, having a total concentration of 20-40 g kg^{-1} (Cornell and Schwertmann, 2003). Fe is frequently present in ferrous (Fe^{2+}) form in primary minerals and few phyllosilicates while its oxidation to the ferric form (Fe^{3+}) showed significant pedogenetic variations (Stucki *et al.*, 2002; Adriano, 2001; Torrent and Cabedo, 1986) and a sequence of conjugate bases formation where Fe was found to be linked with water and hydroxyls (Stumm and Furrer, 1987; Sposito, 1989; Cornell *et al.*, 1989). Goethite (α-FeOOH) and hematite (α-Fe_2O_3) are the most abundant minerals among pedogenic forms of crystalline Fe (hydro) oxides in well-drained soil. Occurrence of other Fe oxides could be seen in poorly drained soil as crystalline minerals (magnetite, lepidocrocite and maghemite) or short-range ordered crystalline minerals (ferroxite and ferrihydrite) or non-crystalline precipitates (Schwertmann, 1985; Cornell and Schwertmann, 2003). Walia *et al.* (2010) reported that the slight increase in the Cu content (1.35-1.66 mg kg^{-1}) was notably observed in plots treated with organic manures over the control plots.

Figure 1 DTPA-micronutrients increased with application of organic matter

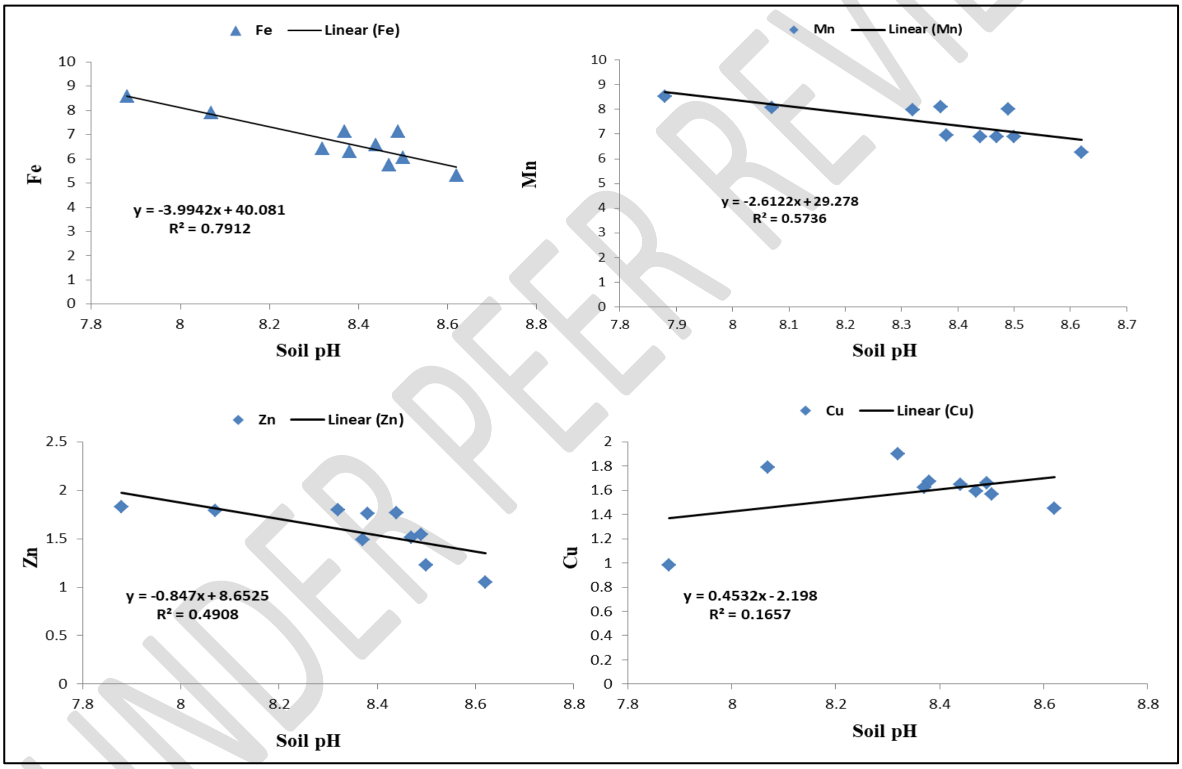


The results indicated that DTPA-micronutrients increased with application of organic matter alone or when it was combined with bio-fertilizers. As vermicompost is rich in micronutrients cations, it might have contributed more to soil. Well decomposed vermicompost and FYM might have involved in formation of organic chelates with organic ligands which have lowered susceptibility to adsorption, fixation and precipitation of micronutrient in the soil and also it was attributed to rapid mineralization of organic manures and consequent release of micronutrients in the soil. Verma *et al.* (2010) reported that higher availability of these micronutrient cations in soil due to application of organic manures and bio-fertilizer was ascribed to the reduction in fixation, increase in mineralization of organic manure and complexing properties of these manures with micronutrients. The release of phenols, aliphatic acids, phenolic acids and stable fraction of humus such as humic and fulvic acids help in chelation of micronutrients and making it more available to plants and Wadile *et al.* (2009).

Relationship between DTPA micronutrients with Soil pH and CEC

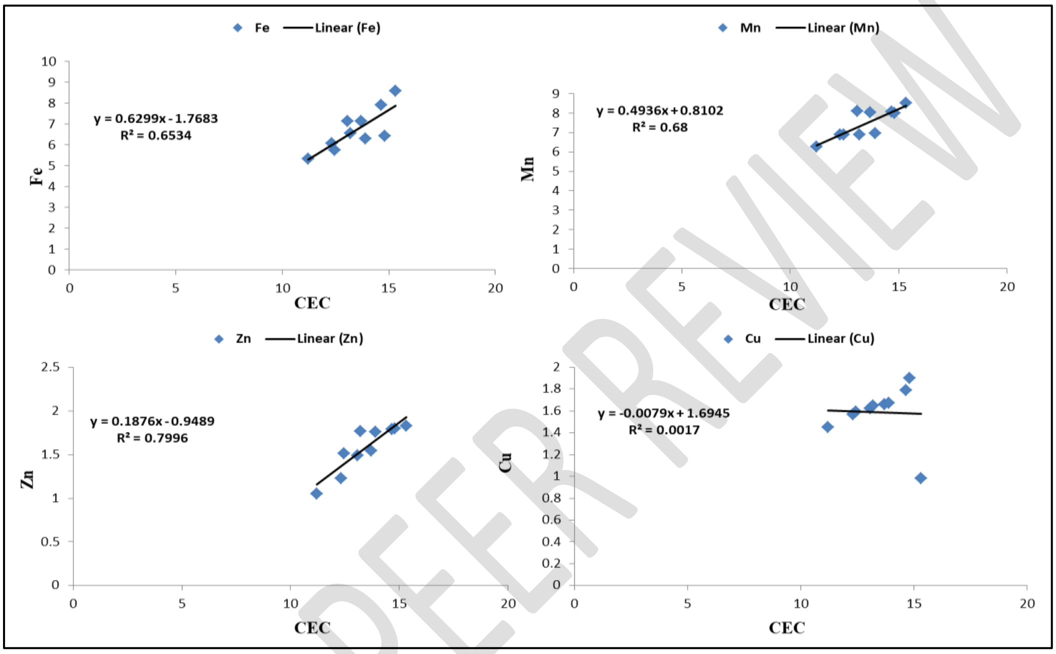
The result regarding correlation was showed that the available Fe (R^2 = 0.79) were significant and negative correlation with soil pH (figure 2). Among the micronutrients available Fe was most negatively correlated with soil pH. In addition to this, with the increase on soil pH by one unit, available iron decreases by 3.99 times and vice-versa.

Figure 2: Relationship between pH and DTPA micronutrient under different nutrient management practices after harvest of pearlmillet under pearlmillet-mungbean system



The R^2 value of correlation between available Mn, Zn, and Cu were 0.57, 0.49, and 0.16. The affinity of copper with organic matter is fairly high so due this available Cu showed the relatively positive correlation to soil pH because added organic manures of reduced the soil pH of soil. The decreased in soil pH may enhance the availability of above micronutrients, this can be noticed in the experimental results that under T10 micronutrients availability was higher because of added organic matter and subsequently decreased in soil pH. Yadav (2011) who suggested that the reduced Fe-availability with increasing pH might be attributed to the conversion of Fe^{2+} to Fe^{3+} ions. The ferric ion (Fe^{3+}) compounds have low solubility in solution and so are less bio-available (Njukeng *et al.* ,2013).The determined result is accordance with the result obtained by Sharma *et al.* (2003); Mathur *et al.* (2006); Yadav (2008); Yadav and Meena (2009) and Sidhu and Sharma (2010). Correspondingly increasing pH, available manganese decreases gradually and vice-versa. Addition to this, with the increase on soil pH by one unit, available copper increased by 0.45 unit and vice-versa. In addition to this, with the increase on soil pH by one unit, available manganese decreases by 2.66 units and vice-versa.

Figure 3: Relationship between CEC and DTPA micronutrient under different nutrient management practices after harvest of pearlmillet under pearlmillet-mungbean system



In contrast to this, the various researcher Sharma *et al.* (2003); Mathur *et al.* (2006); Yadav (2008); Yadav and Meena (2009) and Sidhu and Sharma (2010) found significant and negative correlation between soil pH and available zinc. The result of correlation study showed the positive relation between DTPA Fe, Mn, Zn and cation exchange capacity of soil whereas available Cu showed the negative relationship with CEC (figure 3). The available Fe (R^2 = 0.65) was significant and positive correlation with cation exchange capacity of soil after harvest of pearlmillet. The R^2 values of available Mn and Zn was 0.68 and 0.79, respectively.

Table 4: Descriptive statistics of soil properties

	pH	CEC	Fe	Mn	Zn	Cu
Mean	8.35	13.46	6.71	7.46	1.58	1.59
Standard Deviation	0.22	1.27	0.99	0.76	0.27	0.25
Standard Error	0.07	0.40	0.31	0.24	0.08	0.08
Minimum	7.88	11.21	5.32	6.25	1.05	0.98
Maximum	8.62	15.32	8.58	8.53	1.83	1.90

In addition to this, with the increase on cation exchange capacity by one unit, available iron increased by 0.63 times and vice-versa. The available Cu showed negative relationship with CEC, though R^2 value (0.008) was near to zero and indicating almost neutral relation.

Conclusion

The result of present study showed that relationship between available micronutrients and soil pH was significantly and negatively correlated for DPTA Fe, Mn and Zn. In case of DTPA Cu and soil pH relationship was positively correlated. The highest R^2 value for the relationship between DTPA micronutrients and soil pH was for the available Fe (0 79). The relationship between available micronutrients and cation exchange capacity of soil was reverse of soil pH. Available Fe, Mn and Zn were positively correlated with cation exchange capacity and reverse for DTPA Cu. The lowest R^2 value for relationship between DTPA micronutrients and soil cation exchange capacity was for DTPA Cu (0.008).

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