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Delineating Macro and Micro Nutrients in Soils of Tarn Taran District of Indian Punjab

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Abstract: Soil testing is the best and cheap tool to ensure optimum and balanced use of nutrients. Improper use of fertilizers not only decreased the nutrient use efficiency but also lead to deterioration of the environment. Hence, a block level soil sampling of Tarn Taran district of Punjab, India was planned to assess the macro and micronutrient status of the soils under different cropping systems. A total 160 surface soil samples were collected from farmer fields and analyzed for pH, EC, soil organic carbon (SOC), macronutrients viz. phosphors (P) and potash (K) and micronutrients viz. iron (Fe), manganese (Mn), zinc(Zn) and copper(Cu). Analysis revealed that 92%, 7.3%, and 0.9% samples had normal slight higher and higher pH range while 99.3% samples had normal electrical conductivity(EC) (<0.8 mmho cm^{-1}). 74.7%, 15.3% and 10% samples had medium, low and high organic carbon % (OC%)5.8%, 26%, 56% and 13.3% samples had low, medium, high and very high phosphorus contents. 99.3% of the samples had higher and 0.7% had lower potash values. Parker nutrient index values for OC and phosphorus observed to be in medium range with exception of Tarn Taran and Chohla Sahib. However, in case of potassium, the index observed to be in higher range in all the studied blocks. Correlation analysis reveals that zinc was positively related to soil organic carbon but inversely related to pH and Mn. The pH was also inversely related to Fe, EC, and avail P but directly related to Cu and K. Further, soil samples were sufficient in Fe (68.6%), Mn (62.6%), Zn (93.3%) and Cu (69%). Thus, integrated nutrient management along with soil test based fertilization holds the key to harvest maximum crop yield and maintain soil health which certainly mitigates global warming consequences and improves the livelihoods in the district.

Keywords: Soil fertility, macronutrient, micronutrient, soil organic carbon, soil testing, Parker nutrient Index.

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1 Introduction

Intensive rice-wheat cropping sequence resulted in severe problems *viz.* degradation of soil health, lowering down water table, increase in insect pests and diseases and deficiency of micro- nutrients (Bhatt, 2017a; Bhatt and Kukal, 2017; Bhatt et al., 2016, Humphrey et al., 2010). Under these conditions, agriculture became less remunerative due to the increased cost of cultivation. For improving the water and nutrient use efficiency, computation of soil water balance components viz. irrigation, evaporation, seepage, rainfall, transpiration is a must (Bhatt, 2017b). Government of Punjab has taken a number of steps including Punjab Sub-Soil Water Act 2009, crop diversification, National Horticulture Mission, transplantation of paddy nursery after 10th June etc. In order to ensure higher yields, improve the declining water productivity. Fertilizers application during sensitive plant growth stages is critical to compensate nutrient deficiency. But their excessive application is well-known factor responsible for the low nutrient use effficeency, higher insect-pest attack (Bhatt et al, 2016; Bhatt 2013) and also reduces quality of crop yield (Bhatt, 2013). Therefore, delineation of the inherent soil fertility is imperative before finalizing fertilizer schedule and for which "Soil testing" is mandatory to assess potential of soil to supply nutrient essential for plant growth (Bhatt and Sharma, 2011; Bhatt, 2013; Singh et al, 2016; Bhandari et al., 2002; Latha et al., 2003; Manna et al., 2005). Furthermore, it helps to realize higher response rate and benefit: cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization (Rao and Srivastava, 2000).

"Tarn Taran" is a newly constituted district of the Punjab in 2006. Considering soil fertility studies, it has been reported that nutrient deficiency generally observed in the light textured soils (Sahai, 2010). In the soils of Tarn Taran, deficiency of Zn and Fe reported to be 35 and 1%, respectively and rarely deficient in Mn and Cu. As a whole, Zn deficiency decreased Mn and Fe deficiency increased while there were no significant changes in the Cu status (Singh, 2008). Benbi et al. (2006) have quoted 36, 0.5, 4 and 5 percent soils deficient in available Zn, Cu Fe and Mn, respectively for the district (including Tarn Taran). In a combined study of Amritsar and Tarn Taran districts; available Zn, Mn, Fe and Cu was found to be deficient in 22, 18, 5 and 0 per cent soils, respectively (Singh, 2008).

Moreover, un-judicious use of fertilizers, lack of quality seed, upcoming micro-nutrient deficiencies, declining underground water table, lack of improved crop production and protection technologies, small land holdings, declining soil health, declining water and land productivity are the main challenges in adopting sustainable agriculture (Humpreys et al., 2010). These issues need immediate attention. Keeping this in view, number of technologies viz. use of fertilizers as per soil requirement, zero tillage + mulch (Bhatt, 2017a; Bhatt and Arora, 2015), direct seeded rice (Bhatt and Kukal, 2016; PAU, 2016; Bhatt et al., 2017b), mechanical transplanting of rice, intercropping of wheat grain in the standing rice stubbles, laser leveling, adoption of short duration cultivars, timely transplanting of rice etc., are recommended in the region for overall improvement in the situation. Among all of these, soil testing is the most promising one which also facilitate performance of other strategies (Bhatt and Sharma, 2014; Bhatt, 2013).

The success of any soil management programme depends on an understanding of how the soil responds to agricultural practices over time. Generally, farmers applied heavy dose of fertilizers based on their own understandings and experiences (Manan et al., 2016) without considering inherent fertility of soil and to contribute to low nutrient use efficiency and adverse effects of global warming. Keeping above facts under consideration, present investigation planned for which farmers were randomly selected from all the blocks. A total of 160 soil samples were collected through-out the district. Samples were analyzed in the Department of Soil Science, PAU, Ludhiana, India, for different macro and micro nutrients with the following objectives

1. Delineate soil fertility status in terms of both macro as well as micro nutrients under all the eight different blocks of the district.
2. To study the effect of the cropping patterns on the inherent soil fertility.

2. Materials and Methods

District Tarn Taran lies between 31°7' and 32°3' north latitude and 74°29' and 75°23' in the east longitude and at distance of 105 km from international boundary with Pakistan (Fig.1) (PAMETI 2008). Location wise it situated in the Northwest frontier of Punjab and linked by district Amritsar, Kapurthala, and Ferozepur in the Northeast, East, Southeast directions respectively (Fig.1). The district has 3 tehsils, 4 sub-tehsils and 5 assembly constituencies and 1 Lok-sabha constituency (PAMETI 2008). It has eight blocks viz. Bhikhiwind (31,970 ha), Chohla Sahib (26,725 ha), Gandiwind (16,201 ha), Khadaur Sahib (28,805 ha), Naushehra Pannuan (29,242 ha), Patti (35,777 ha), Tarn Taran (36,122 ha) and Valtoha (36,607 ha) (PAMETI 2008).

Table 1: Methodological approach used for analysis of soil samples

Sr. No	Parameter analyzed	Method used
1.	pH	1:2 soil-water suspension using the method (Jackson, 1967).
2.	Electrical conductivity (m mho cm^{-1})	1:2 soil-water suspension using the method (Jackson, 1967).
3.	Organic carbon (%)	Walkley and Black's rapid titration method Walkley and Black (1934).
4.	Soil Texture	International pipette method (Day, 1965).
5.	Soil Phosphorus	0.5 N $NaHCO_3$ extractable P (Olsen et al 1954).
6.	Soil Potash	Ammonium acetate extractable K (Jackson 1967).
7.	Zinc	These micronutrients extracted from the soil by the DTPA method (Lindsay and Norvell, 1978) and determined in the soil extracts with atomic absorption spectrophotometer (AAS).
8.	Copper	
9.	Iron	
10.	Manganese	

Fig. 1 Geographical location of the studied district viz. Tarn Taran of Indian Punjab

Table 2: Nutrient index with range and remarks

Nutrient index	Range	Remark (OC, P_2O_5, K_2O)
I	Below 1.67	Low
II	1.67- 2.33	Medium
III	Above 2.33	High

From South-West side, district is bounded by Beas River. Extremes climatic conditions are regular feature of the area as summers are quite hot while winters are quite cold. Monsoon months restricted to July to September with a seasonal average of 650 mm. Soil texture varied from sandy loam to loamy sand. In areas of Patti, Gandiwind and Bhikhiwind blocks of the district have alkaline soils (PAMETI, 2008). Around 99% of the area is irrigated out of which canal (65%) and tubewells (35%).

For present investigation, soil samples (20 per block) were collected from 0-15 cm depth in a zig-zag pattern using the standard procedure for soil sampling and sample preparation (Andreas and Micheal, 2005). All the samples were air dried in shade, crushed gently with pestle and mortar, then subsequently sieved through 2.0 mm stainless steel sieve to obtain a uniform sample and stored in cloth bags. Detail information pertaining to field and farmer viz. name, village, block, district etc. was also provided with each sample. The methodological aspect of the analysis of the samples being well documented (Table 1).

Table 3: Chemical properties soil samples from different blocks in the Tarn Taran district of Punjab, India

Blocks	Major cropping sequence	pH	EC (m mho cm^{-1})	Soil texture	OC (%)	P_2O_5 (kg $acre^{-1}$)	K_2O (kg $acre^{-1}$)
Chohla Sahib	Rice-wheat, vegetables	7.77	0.33	LS	0.54	14.53	144.1
Tarn Taran	Rice-moong-wheat, vegetables	7.93	0.31	LS	0.66	14.56	202.0
Valtoha	Rice-wheat, Vegetables	8.57	0.25	LS	0.55	12.03	185.8
Bhikhiwind	Rice-wheat, Horticulture, vegetables	7.88	0.35	SL	0.60	12.11	135.8
Patti	Rice-wheat, Horticulture	7.96	0.36	SL	0.55	13.01	192.4
Naushehra Pannuan	Rice-wheat	7.59	0.28	SL	0.45	12.61	131.4
Gandiwind	Rice-wheat	7.99	0.28	SL	0.46	13.91	148.8
Khadaur Sahib	Rice-wheat, oilseeds	8.27	0.18	SL	0.57	12.69	166.1
Mean		7.99	0.25		0.55	13.18	163.3

LS loamy sand while SL are Sandy loam delineates divergent soil textural classes.

2.1 Parker's Nutrient Index (PNI):

A single value of each nutrient is required for making a comparison of fertility of one area with that of another for which index suggested by Parker et al, 1995 is useful. The percentage of samples in each of three classes viz. low, medium and high were multiplied by 1,2 and 3 respectively. The sum of values thus obtained was divided by 100 to give the index value (Table 2). Three tier system

$$PNI = \frac{X1 \times 1 + X2 \times 2 + X3 \times 3}{\text{Total number of samples}}$$

X1 = Number of samples which are low.
X2 = Number of samples which are medium.
X3 = Number of samples which are high.

3. Results and Discussion

3.1 Physico-chemical properties of soils

3.1.1 Soil pH

Soil pH delineates the acidity or alkalinity of a soil. Soil pH provides an idea about soil properties, activity of nutrients and influences nutrient supplying capacity of the soil. Plant mainly uptake nutrients dissolved in soil solution. In our analysis, pH ranges from 7.10 to 9.30 with a mean value of 8.0. Higher range of pH may be due to soluble and exchangeable sodium ions along with bicarbonate ions, which precipitate as calcium and magnesium carbonate during evaporation. Alkalinity problem in some pockets may be due to indigenous calcareous parent material with typical low organic matter content (Weli and Brady, 2016).

Rice-wheat cropping sequence is the most popular and adopted in the region. Wide window period exists in between rabi and kharif seasons. Hence, first soil testing is there and then after, green manuring followed by gypsum application recommended in the region for improving both land productivity and soil health. Further, retention of crop residues on the soil surface along with fertilization in proper combination with organic manures will certainly improve the declining soil health and enhance crop productivity (Sainju et al. 2008) as this will provide the benefit of the mulch loads. Our analysis confirmed that EC of Tarn Taran district ranged from 7.77 to 8.57with a mean value of 7.99 (Table 3). Correlation analysis revealed that pH inversely related to Fe, EC and avail P but directly related to Cu and K (Table 6).

3.1.2 Electrical conductivity (EC)

Electrical conductivity (EC) is measure of soluble salts present in the soil solution and certainly effected by the irrigation water quality, soil type, applied fertilizers and adopted crop rotation, and finally land productivity. Excessive salts hinders nutrient uptake by the plant's roots might be due to an imbalance in ion uptake, antagonistic effect between osmatic potentials of soil solution or between nutrients or combination of all (Rahman et al, 2010). Carried out analysis confirmed that EC of Tarn Taran district varied from 0.10 to 0.52 m mho cm^{-1} with a mean value of 0.25m mho cm^{-1} (Table 3). However, Patti block reported with highest values (0.36) while Khadoor Sahib reported with lowest values viz. 0.18mmho cm^{-1}. Correlation analysis revealed that pH inversely related to EC (Table 4).

3.1.3. Soil Texture

Soil texture delineates the relative proportion of sand, silt, and clay which further affect almost all the physicochemical properties of the soils. Soils of Tarn Taran district are texturally divergent in nature as varied from loamy sand (Chohla sahib, Tarn Taran, and Valtoha) to sandy loam (Bhikhiwind, Patti, Naushehra Pannua, Gandiwind and Khadaur Sahib) in texture (Table 3).

Table 4. Correlation matrix between micro and macro nutrients and properties of soils of Tarn Taran district, Punjab

	Available **Zn**	Available **Fe**	Available**Mn**	Available **Cu**	Available **P**	Available **K**
Available Zn	1					
Available Fe	0.185*	1				
Available Mn	0.021	-0.027	1			
Available Cu	0.162*	-0.023	0.352**	1		
Available P	-0.001	0.016	0.115	0.065	1	
Available K	0.062	-0.075	0.270**	0.042	0.398**	1
Soil pH	-0.261**	-0.182*	-0.009	0.060	-0.136	0.179*
EC	0.205*	-0.139	0.142	0.047	0.280**	0.391**
OrgC	0.125	-0.071	0.234**	0.192*	0.335**	0.359**

*,** Correlation is significant at the 0.05 and 0.01 level.

Table 5: Spatial variations in Nutrient Index Value (NIV) of soils with respect to macro-nutrients

Blocks	OC	P_2O_5	K_2O
Chohla Sahib	1.83	2.89	2.78
Tarn Taran	2.11	2.89	3.00
Valtoha	1.89	2.06	3.00
Bhikhiwind	2.06	2.06	3.00
Patti	2.06	2.00	3.00
Naushehra Pannuan	1.68	2.05	3.00
Gandiwind	1.78	2.17	3.00
Khadaur Sahib	2.00	2.04	3.00
Mean	7.99	0.25	0.55

OC, organic carbon.

3. 2. Macro-nutrient status of Soils:

3.2.1 Organic carbon (%)

Organic carbon is the main factor that decides inherent soil fertility as it influences physical, biological and chemical properties of soil (Bhatt, 2017a; Rasul et al., 2016; Iqbal et al., 2015). Further, organic matter has a vital role to play in agricultural soils as it supplies plant nutrient, improves the soil structure, improves water infiltration and retention, feeds soil micro flora and fauna, and the retention and cycling of applied fertilizers (Johnston, 2007; Nikolaidis and Bidoglio. 2013 Debicka et al., 2016; Paul, 2016; Mia et al., 2017). Present investigation revealed that O.C% status of the district mostly in the middle range viz. 0.4 to 0.75%. Highest status reported in Tarn Taran block (0.66%) which might be due to residue incorporation, adopted green manuring practice because of timely supply of green manure crop seeds at subsidized rate by the State government and awareness of the farmers (Table 3).

Crop residue incorporation increased OC content in the soil more significantly than straw burning or removal. Soil OC showed an increasing trend with time in all theresidue incorporation (Singh et al, 2004). Lower organic carbon values in Naushehra Pannuan and Gandi wind block might be due to residue burning in intensively cultivated rice-wheat cropping sequence. The mean O.C% value of the district across the all eight blocks delineated to be 0.55%. Therefore, farmers with lower OC% content in their fields must be encouraged to adopt integrated nutrient management based on the soil test based fertilization along with proper use of organic manures (Mishera et al, 2014).

3.2.2 Available Phosphorus

Phosphorus is the second macro-nutrient which is necessary for the plant growth. Phosphorus is essential for growth, cell division, root growth, fruit development and early ripening of the crop (Elser, 2012; Nemery, J. and J. Garnier, 2016; Rowe et al., 2016; Roy et al., 2016; Chen et al., 2017). It is also required for energy storage and transfer is a constituent of several organic compounds including oils and amino acids. The plants take available P mostly in the form of H_2PO_4 **-** from the soil solution. Chemisorptions of P occur due to the interaction of phosphate ions with the atoms like aluminium (Al), iron (Fe) or calcium (Ca) depending upon soil pH (Sahai, 2010; Duffner et al., 2012; Ma et al., 2016).

Current study states that soil phosphorus in the district varied from 3.7 to 31.5 kg acre^{-1}with a mean value of 13.18 kg acre^{-1}(Table 3). Valtoha block reported with lowest P status while Tarn Taran block has highest P value viz. 14.56 kg acre^{-1}which might be because of the already explained reason of green manuring (Table 3). Further, 5.8% of the samples having P less than 5 kg acre^{-1} (low), 26% samples having 5-9 kg acre^{-1}(medium), 56% samples fall in range 9-20 kg acre^{-1} (high) while 13.3% samples having more than 20 kg acre^{-1} (very high).Thus, all the blocks of Tarn Taran district having high P status thus its application could be skipped during rice season or may be applied as per recommendations based on the soil test reports. Correlation analysis revealed that pH inversely related to available P thus its availability increased relatively in the lower range of pH (Table 4).

3.2.3 Available Potassium:

Potassium exists in K^+ form with catalytic nature, therefore participates in the activation of a large number of enzymes which are involved in various physiological process of plants (Amtmann et al., 2008; Manning, 2005; White and Karley, 2010; Zhan et al., 2016). Further, it controls the water economy and provides the resistance against a number of pests, diseases and environmental stresses (A Cakmak, 2005;Amtmann et al., 2008; Romheld and Kirby, 2010; Sahai 2010; Ahmad and Mathuis, 2104). Earlier it was assumed that in the Punjab's soils, sufficient in potash contents due to the formationfrom potash-rich parent material and therefore rarely required supplementation of potash fertilizers. However, recent reports revealed that there is a response to the added fertilizer depicting that reserves of potash in Punjab soils are now not sufficient enough to meet the needs of growing plants (Bhatt and Sharma, 2011). Throughout the district, potash status varied from 24.5 to 357 kg acre^{-1} with a mean value of 163.01 kg acre^{-1}.

Table 6: Micro-nutrient status in the Tarn Taran district of Punjab, India

	Zn	Fe	Mn	Cu
Blocks	mgkg^{-1}			
Chohla Sahib	1.73	26.80	4.32	1.13
Tarn Taran	2.30	26.00	5.75	1.68
Valtoha	1.58	22.33	5.84	1.50
Bhikhiwind	2.58	21.05	4.76	1.49
Patti	3.60	33.85	5.03	1.51
Naushehra Pannuan	2.77	35.13	4.51	1.27
Gandiwind	2.03	41.63	4.44	1.32
Khadaur Sahib	1.91	42.13	3.22	1.18
Mean	2.31	31.11	4.73	1.39

Number of total collected soil samples 160

Naushehra Pannuan block reported with minimum values viz. 131.4 kg acre^{-1} while Tarn Taran having highest mean values viz. 202 kg acre^{-1} which might be because of adopted green manuring practice. Further, among total collected 160 soil samples, 99.3% samples reported having more than 55 kg acre^{-1} (high) while 0.7% samples have lower values than 55 kg acre^{-1}delineating almost nil potash deficiency (Table 3). Thus, based on present investigation, site-specific application of potash fertilizer only in soils with insufficient soil potash contents will certainly improve the land productivity. Correlation analysis revealed that pH directly related to K and its increase favored the availability of Potassium (Table 4).

3.3 Parker nutrient index values (NIV)

Nutrient index value (NIV) is the measure of nutrient supplying capacity of the soil to plants with respect to any particular nutrient (Saarinen et al., 2017). The data (Table 5) implies that the nutrient index of OC% was observed to be medium in range. However, no block falls in the low or high category. Higher values observed in the Tarn Taran block because of adopted practicedgreen manuring while lowest values (Naushehra Pannuan) can be attributed to intensive rice-wheat cropping sequence and burning of crop residues. In case of phosphorus the highest nutrient index values were recorded in Chohla Sahib and Tarn Taran blocks followed by Gandi wind while all other blocks having almost similar values and this might be due to already explained reasons.

Coming over to the potassium, all the blocks have higher values of NVI, depicting higher potassium status of the district in all the blocks with exception of Chohla Sahib as here farmers are still not using K fertilizers (Table 5). The observed difference in the NIV in the different village was probably due to the difference in the cropping sequence being followed by the farmers.

3.4 Micronutrient status of soils

3.4.1 Available Zn

Available Zn content in the soils of Tarn Taran district varied from 1.58 to 2.77mg kg^{-1}with a mean value of 2.31mg kg^{-1}soil (Table 6). Considering 0.60 mg kg^{-1}, Zn as optimum dose, it observed that 93.3% of samples have higher while 6.7% samples havelower range of zinc status in soils. Thus, farmers need to go for zinc fertilization based on their soil test reports and in case of lower side go for 25 kg $ZnSO_4$ heptahydrate (21%) or 16 kg $ZNSO_4$monohydrate (33%) per acre in rice while in wheat, 0.5% spray of $ZnSO_4$ used to correct this deficiency so as to have the potential yields. Correlation analysis revealed that zinc was positively related to soil organic carbon but inversely related to pH and Mn (Table 4).

3.4.2 Available Fe

Available Fe content in the soils varied from 21.05 to 42.13mg kg^{-1}with a mean value of 31.11mg kg^{-1} (Table 6). Considering 4.50 mg kg^{-1} Fe as optimum level it observed that 98.6% of samples have higher (Table 6) while 0.4% samples have deficient range of iron status in soils. Thus, farmers reported with lower range of Fe, might apply 2 to 3 sprays of 1% solution of $FeSO_4$ for spray to correct this deficiency in rice crop. Correlation analysis revealed that pH inversely related to Fe (Table 4).

3.4.3 Available Mn

Available Mn content in the soils of Tarn Taran district varied from 3.22 to 5.84mg kg^{-1}with a mean value of 4.73 mg/kg soil (Table 6). Considering 3.50 mg kg^{-1}, Mn as optimum dose it observed that 62.6% of samples have higher while 37.3% samples havelower range of manganese status in soils. Therefore, almost all the blocks light textured in particular showing a higherside of manganese deficiency. Thus, manganese deficiency quite often observed during the wheat season which could be easily ameliorated by spraying 0.5% $MnSO_4$ solution.

3.4.4Available Cu

The available Cu content in the soils of Tarn Taran district varied from 1.13 to 1.68mg kg^{-1}with a mean value of 1.39mg kg^{-1}soil (Table 6). Present investigation reported with nil deficiency of Cu, however, no sample showing Cu deficiency while 4% samples come in medium range i.e 0.20-0.50 mg kg^{-1}, range while 96% samples have a higher range (> 0.50

mg kg^{-1}). Correlation analysis revealed that pH directly related to Cu (Table 4).

3.5 Effect of cropping sequence on soil fertility

Different agricultural practices used to prepare the seed bed for the next crop will always have a definite effect on the soil structure viz. for rice puddling is the most commonly used practice which effects most of the physicochemical properties of soil (Bhatt, 2015). Moreover, repeated puddling of coarse and medium textured soils in the state has led to the sub-surface compaction in these soils (Sur et al 1981) which has been proving detrimental for the upland crops like wheat (Bhatt and Kukal, 2017). The high bulk density layer at 15-20 cm depth formed due to repeated puddling restricts the root growth of wheat in addition to creating aeration stress (Aggarwal et al 1995). Thus, puddle transplanted system of rice is water, capital, and energy intensive and leads to structural deterioration of the soil.

Our study also revealed that the blocks following intensive rice-wheat cropping sequence showed lower soil fertility in comparison to those where integrated nutrient management is being followed (Table 3). Tarn Taran blocks showed higher OC values because of practiced green manuring while a contrast to it some blocks viz. Naushehra Pannuan and Gandi wind showed lower OC values and more dependency on fertilizers because of intensive followed rice-wheat cropping sequence. Further, options to practice climate-smart agriculture/sustainable agriculture are more in blocks where integrated nutrient management is being followed. Therefore, farmers are encouraged to diversify some area from rice-wheat to other oilseed/pulses crops or to go for integrated nutrient management.

3.6 Correlation of soil chemical properties

Fertilizer requirement varies with the soil test values for a particular target yield (Mishra et al. 2014; Singh et al. 2014). Adopted cropping sequence practices significantly influence soil chemical properties of the district. It wasearlier observed that blocks under rice-wheat cropping sequence viz. Naushehra Pannuan and Gandi wind intensively followed had adversely effected soil health followed by the emergence of new micro-nutrients which if not attended properly causes a decline in land productivity. However, blocks where green manuring practiced viz. Tarn Taran by the farmer on regular basis has an edge in soil health. Further micro-nutrient deficiency extent decreased to many folds. Correlation analysis provides us clear picture about the relationship between different micro and macro nutrients. Framed table clearly depicted that zinc was positively related to soil organic carbon but inversely related to pH and Mn. The pH was also inversely related to Fe, EC and avail P but directly related to Cu and K (Table 4).

Available Zn and Fe was negatively and significantly correlated with soil pH (r=-0.261* and r=0.182*). Positive relationship between available Zn, Mn and Cu was observed with soil EC (r=0.205*, 0.142 and 0.047). Available Zn was positive but non-significantly correlated with soil org C content (r=0.125) while it was significant in case of available Mn and Cu with coefficient values of 0.234** and 0.192* respectively. Available P was negatively correlated with soil pH while significantly and positively with soil EC (r=0.280**) and org C content (r=0.335**). Similarly, available K content was significantly and positively related with soil pH, EC and org C content with coefficient values of 0.179, 0.391 and 0.359, respectively.

Interrelationship shows that available Zn was positive and significantly correlated with available Fe and Cu content. Highest significant and positive relationship of observed between available Mn and Cu content with coefficient of 0.352. Available Mn and available K content were also positive and significant in relationship (r=0.270**) in the soils of Tarn Taran district of Punjab.

4. Conclusion

The physico-chemical properties of soil were analyzed for all the 8blocks of district Tarn Taran. The parameters such as pH, EC, OC, available phosphorus, available potassium, and micro-nutrients viz. Cu, Zn, Mn and Fe were undertaken for the present investigation. Data pertaining to pH revealed villages with pH>9.3 generally follow the paddy-wheat rotation. Blocks with high soil OC generally, follow vegetable based cropping system/green manuring which enriches the soil with *in situ* decomposition and high fertilizer use. Carried out analysis revealed that74.7%, 15.3%, and 10% samples had medium, low and high range of organic carbon while 5.8%, 26%, 56% and 13.3% samples had low, medium, high and very high phosphorus contents. Coming on to potassium 99.3% of the samples had higher and 0.7% had lower potash values. As far as micronutrients are concerned, 93.3% and 98.6% samples had higher Zn and Fe status while 62.6% and 69% of the samples had a higher range of Mn and Cu while no sample reported with Cu deficiency. Results clearly indicated that Tran Taran soils are neutral in pH, normal in EC, medium in O.C

(%), higher in P and K while sufficiently rich in zinc, iron, manganese, and copper. But the farmers applied more fertilizers ignorantly without testing their soils Therefore, soil test based fertilization along with proper use of organic manures viz. green manure, poultry manure, vermicomposting etc. will only serve the purpose to reduce the cost of cultivation which will further improve the livelihood on one side while helps in mitigating global warming consequences by minimizing the reducing the magnitude of N_2O and NO_2 gas emissions.

List of abbreviations: EC: electrical conductivity; OC: organic carbon.

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