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Full Length Research Paper

Evaluation of the fertility status of the rice tract area of Jafarabad district, Baluchistan Pakistan

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Laboratorial experiment was conducted to analyzed the nutrient status (macro and micronutrients) and physical and chemical properties of soils of rice tract area of Jafarabad district, Baluchistan. For this fifty (50) sites were selected to collect soil samples at both 0-15 and 15-30 cm depth. Soil physical parameters (EC, pH, texture, organic carbon hence organic matter and $CaCO_3$) as well as chemical nutrient contents including total N, Olsen P, extractable AB-DTPA (K, Cu, Fe, Mn and Zn) were determined. The data showed that the majority of the soils in the study area were heavy to medium in texture, calcareous in nature, non-saline, alkaline in reaction, and low in organic matter which decreased markedly with increase in soil depth. The levels of total N and Olsen P were deficient in all soils. However, exception was the extracable- K which was moderate. It was observed from the results that the concentration of micronutrients varied with the increase in soil depth. The levels of soil total N, Olsen P, extractable AB-DTPA (Zn, Mn, Cu and Fe) were generally low at the depth of 15-30 cm. pH ranged from 7.6 to 8.7. The texture of the soils was almost clayey which increased the variation and dynamics of the studied nutrient elements with the soil depths. It was then realized that a soil depth of 0-15 cm favoured availability of most plant nutrients in the study area.

Key words: Clay soil, soil properties, nutrient status, macro and micronutrients

INTRODUCTION

Geographical area of Baluchistan is 34.7 M ha (or 85.74 million acres) of which 2.06 million acres of land is cultivated. District Jafarabad is famous as agricultural regions. The cultivable land of the country have derived from alluvium and loess, and are low in organic matter and many essential nutrients. Soil fertility determines the growth of plant as well as presence or absence of nutrients of macro and micronutrient. An adequate supply of plant nutrients is the prerequisite for the maximum agricultural production along with favourable environmental conditions. The group of essential elements includes both macro and trace elements. The group of essential nutrient includes both non-mineral (carbon (C), oxygen (O) and hydrogen (H) and mineral (N, P, K, Ca, Mg, S, Fe, Cu, B, Mn, Mo, Zn, and Cl) used by plants. Basic three nutrients are nitrogen (N), phosphorus (P) and potassium (K) are called primary macronutrients. Calcium (Ca), magnesium (Mg) and sulphur (S) are called the secondary macronutrients including are required in relatively large amounts. These nutrient elements are the important constituent in the soil that promotes plant growth (Rashid and Memon, 2002). Other elements such as B, Cu, Fe, Mn, Mo and Zn are called “trace elements” often called “micronutrients” because they are required by the plant in small quantities (Alloway, 1990; Brady and Weil, 2002). The deficiency of Zn, Fe and Cu is a common feature of the soils of the study area. Being arid to semi-arid area, about 75 % of the cultivated area is irrigated while the rest is rain-fed.

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During the era of "Green Revolution", the varieties of high yielding crops were introduced and their high demand for nutrients also contributed to increased amounts of macro and micronutrients mining, which led to their deficiencies.

Fertilizer application practices in Pakistan generally related to N and P only, whereas the use of K is limited to a few high K requiring crops such as sugarcane and potatoes. Nitrogen is the most important plant nutrient, building blocks of almost all plant structures (Brady and Weil, 2008). N is a important component of chlorophyll, enzymes, proteins, stimulates root growth and crop development as well as uptake of the other nutrients (Smil, 2001). Phosphorus is required in high concentration at the growing points of roots, shoots, as part of nucleic acids, phospholipids and energy storing/transferring systems in the plant (Devln, 1982). Potassium is used as a catalyst, in important reactions such as respirations, photosynthesis, chlorophyll formation, and water regulation. Micronutrients are part of the enzyme system and thus regulate plant life (vitamins, proteins fats, and chlorophyll, flowering, fruit setting and fruit ripening (Pathak et al., 2011). Copper is associated with a many metalo-proteins, carbohydrate metabolism, N2 fixation, photosynthesis, respiration, de-toxification of superoxide radicals and lignifications (Rohheld and Marschner, 1991).

Iron is a part of chlorophyll that is responsible to increases photosynthesis and net assimilation (Sultana et al., 2001). Zinc is associated with many enzymes, formation of chlorophyll, pollen functioning and fertilization (Kaya and Higgs, 2002). Much of the determination of fertility status research on different areas of Pakistan is related to Hyderabad Tandojam (Oad, et al, .2003), TandoAllahyar (Kashmiri, 2001), Pano Akil (Malik, 2001), Hala (Memon, 2005). Chhabra et al. (1996) conducted the study on micronutrient (Cu, Fe and Mn) available Mn and Fe decreased with decrease in soil pH and in sand content and available Cu increased with increase in clay and organic carbon. Electrical conductivity is a simple method to determine soluble ions of the soils. pH is a ability to determine available nutrients in the soil and plant. Nazif et al. (2006) evaluated the status of available micronutrients in Jhunjhunu Tehsil (Rajsthan) and district Bhimber. Considering the momentous of nutrient status and a need for scientific approach to study the characteristics of the soils, the present study was conducted to analyze physic-chemical properties of rice tract area of Jafarabad Balochistan.

MATERIALS AND METHODS

Site description

Soil sampling in the field and laboratorical analysis of physic-chemical parameters was carried out in rice tract area of district Jaffarabad Baluchistan, Pakistan. The district is located between latitude 28° 16.7' and longitude 68° 26.7' . The total geographical area of the district is 244,500 ha in which 220,000 ha are the cultivated lands. The total rice producing area is 70,500 ha and wheat is 78,880 ha. The summer temperatures are between 35 and 53°C which favour the cultivation of different crops. Major crops are growing such as dates, barley, sorghum, millet, pulses, onions, potatoes, chillies and fodders. Rice, sugar-cane, tobacco, gram, mash and castor bean are the second in production levels. There is shortage of water in the area.

Soil sampling

Soil samples were collected from 50 different rice growing areas in cultivated fields of the district Jafarabad. One hundred (100) soil samples representing two soil depths of 0-15 and 15-30 cm were collected in a zigzag pattern. Three soil cores at the depth of 0-15 cm were collected from each site and composited to form one sample. The soils were stored in polythelene bags in the field and kept cool. Prior to laboratory analysis process, the soil samples were air dried, roots and other recognized plant materials were removed, the soil was sieved to separate gravel ground to pass through 2 mm sieve and stored in plastic bottles for subsequent soil analysis.

Physical and chemical analysis of the study soil

Soil pH (alkalinity and bacidity) and electrical conductivity (EC) soluble ions were determined in a 1:2 soil-water extract using pH and EC meter, respectively. Soil texture was determined by the hydrometer method (Bouyoucos, 1936), soil organic carbon by Walkley–Black method and corrected to organic matter by Vant Hoof's factor (1.724) (Jackson, 1962), total N was determined by Kjeldahl distillation (Bremner, 1965), lime analysis by acid neutralization method (Jackson, 1969). Available P was determined by the Olsen $NaHCO_3$ extraction (Olsen et al., 1954) followed by colour development using ascorbic acid method as described by Murphy and Riley (1962). Exchangeable K was determined by extraction with 1 N NH_4OAC (CH_3COONH_4) followed by subjecting the extract on an emission flame photometer as described by Knudsen et al. (1982). The extractable micronutrients (Cu, Fe, Mn and Zn) were determined by (AB-DTPA) method of Soltanpour and Schwab (1977) and the extracts were subjected to atomic absorption spectrophotometer (AAS).

RESULTS

Physical characteristics of the soils

The physical parameters of the soil are presented in Table 1. Electrical conductivity (EC) ranged from 0.15

Table 1: Physical parameters of soils collected from rice tract area of District Jaffarabad Baluchistan.

Parameters	Range	Mean	Low	Medium	High
		0 – 15 cm			
Ec dSm^{-1}	0.15 – 6.89	2.81	0 – 4 37 (74)	4 – 8 13 (26)	> 8 0(0)
pH	7.6 – 8.7	8.10	> 7 0(0)	7 - 9 50 (100)	> 9 0 (0)
O.M %	0.28 – 1.08	0.58	<0.89 46(92)	0.89 – 1.26 4 (8)	> 1.26 0(0)
$CaCO_3$ %	8.3 – 18.21	13.59	0 – 7 0 (0)	7– 14 32 (64)	> 14 18 (36)
		15 – 30 cm			
Ec dSm^{-1}	0.13 – 4.10	2.01	0 – 4 49 (99)	4 – 8 1 (1)	> 8 0(0)
pH	7.5 – 8.80	7.94	> 7 0(0)	7 - 9 50 (100)	> 9 0 (0)
O.M %	0.10 - 0.89	0.43	<0.89 1(1)	0.89 – 1.26 49 (99)	> 1.26 0(0)
$CaCO_3$ %	8.21 – 16.95	12.09	0 – 7 0 (0)	7– 14 38 (76)	> 14 12 (24)

to 6.89 dS $m^{-1}$with mean value of 2.81 dS m^{-1}, pH ranged from 7.6 to 8.7 with mean value of 8.10, organic matter (% O.M) ranged from 0.82 to 1.0 % with mean value of 0.58 %, and $CaCO_3$ ranged from 8.3 to 18.2 % with mean value of 13.59 %. All soils were low to medium or slightly saline in 74 % and slightly alkaline (4-8 dS m^{-1}) in 26 % samples. The O.M was low (< 0.89 %) in 92 % samples and sufficient (0.89 – 1.26 %) in 8 % samples at 0-15 cm but it was low in 1 % and sufficient 99 % at 15-30 cm soil depth. The percentage $CaCO_3$ was medium (7-14 %) in 64 % samples and high (> 14 %) in 36 % range and in 76 % and high (24 %) at 15-30 cm soil deep. The majority of the studied soils (81 %) were clayey in texture followed by sandy clay (13%) and silt clay (6 %). The results revealed that the values of Ec decreased with soil depth and accumulation of salts in the surface layers might be due to low rainfall, high evaporation rates and capillary movement of salts. The soils were poor in organic matter and it ranged between 0.10 and 1.00 % and it decreased markedly with the increase in soil depth. The soils were also calcareous in nature.

Nutrient contents of the study soils

The contents of total N of the surface soils (0-15 cm) ranged from 0.011 to 0.069 % with mean value of 0.39 % whereas in the sub-surface soils it ranged from 0.03 to 0.06 % with average values 0.34 %. The content of N was low (< 0.05 %) in 84 % soil samples and medium (0.05 – 0.1 %) in 16 % soil samples for the surface soils whereas N in the subsurface soil samples was low in 94 % and medium in 6% soil samples. Phosphorus contents of surface soils was medium which ranged from 8.12 to 25.33 ppm with mean values 15.57 ppm whereas in the sub-surface soils it rangedfrom 3.33 – 18.22 ppm with an average value of 9.69 ppm. Available P was low (<10 ppm) in 12 % and medium in 32 % soil samples at 0-15 cm soil depth but it was low in 58 %, medium in 33 % and high in 8 % soil samples at 15 – 30 cm soil depth. The contents of K in the surface soils ranged from 47 to 222 ppm with mean value of 110 ppm whereas it ranged from 60 to 160 ppm in the sub-surface soil with an average value of 100 ppm.

Potassium was low (< 60 ppm) in 2%, medium (60 – 120 ppm) in 60 % and high (> 120 ppm) in 38% in the surface soils but in case of 15 – 30 cm soil depth K was medium in 78 % and high in 22% soil samples. The contents of micronutrients in soils revealed wide spread of Zn deficiency in rice fields of Jaffarabad Baluchistan district (Table 2). Copper contents of surface soils ranged from 0.37 to 5.60 ppm with mean value of 3.10 ppm whereas in the sub-surface soils Cu ranged from 0.23 to 5.78 ppm with mean value of 1.95 ppm. Iron contents in the surface soils ranged from 2.98 to 15.29 ppm with mean value of 9.73 ppm, whereas in the sub-surface soils Fe ranged from 2.12 to 12.11 ppm with an average value of 6.26 ppm. Manganese ranged from 8.34 to 18.9 ppm with mean value of 12.28 ppm at 0 – 15 cm soil depth and from 1.67 to 15.89 ppm with mean value of 7.90 ppm at the soil depth of 15 – 30 cm. Zinc ranged from 0.07 to 0.87 ppm with an average value of 0.32 ppm at 0 – 15 cm soil depth and it ranged from 0.04 to 0.32 ppm with an average value of 0.23 ppm in sub-surface soils. Results indicated that the AB-DTPA extractable micronutrients including Cu, Fe, Mn and Zn in soils were adequate

Table 2: Macro and micronutrient contents in rice tract area of District Jaffarabad Baluchistan

Parameters	Range	Mean	Low	Medium	High
		0-15 cm			
N %	0.011 – 0.069	0.039	> 0.05 42 (84)	0.05 – 0.1% 8 (16)	< 0.11 0 (0)
P ppm	8.12 – 25.33	15.57	0-10 6 (12)	10 - 15 28 (56)	> 15 16 (32)
K ppm	47 – 222	110	< 60 1 (2)	60 - 120 30 (60)	> 120 19 (38)
Cu ppm	0.37 – 5.60	3.10	< 0.5 2 (4)	> 0.5 48 (96)	
Fe ppm	2.98 – 15.29	9.73	< low 0 (0)	> 2.4 3 (6)	> 4 (47) 94
Mn ppm	8.340 – 18.9	12.28	< 1.8 0 (0)	> 1.8 50(100)	
Zn ppm	0.07 – 0.87	0.32	< 0.8 49 (98)	> 0.8 1 (2)	
		15-30 cm			
N %	3.33 – 0.06	0.034	> 0.05 47(94)	0.05 – 0.1 3 (6)	< 0.1 0 (0)
P ppm	3.33 – 18.22	9.69	0-10 29 (58)	10 - 15 17 (33)	> 15 4 (8)
K ppm	60 – 160	100	< 60 0 (0)	60 - 120 39 (78)	> 120 11 (22)
Cu ppm	0.23 – 5.78	1.95	< 0.5 5 (10)	> 0.5 45 (90)	
Fe ppm	2.12 – 12.11	6.26	< 2 0 (0)	> 2- 4 12 (24)	> 4 38 (76)
Mn ppm	1.67 – 15.89	7.90	< 1.8 2 (4)	> 1.8 48 (96)	
Zn ppm	0.04 – 0.32	0.23	< 0.8 50 (100)	> 0.8 0 (0)	

* = Number of samples
** = percentage of samples

that is Cu (> 0.5 ppm), Fe (> 4 ppm) and Mn (> 1.8 ppm) in both soil depths. However, 98 % of the soils were low in Zn and only 2 % of the soils were adequate in Zn at the soil depth of 0 – 15 cm and 100 % of the soils was low in Zn at 15 – 30 cm depth.

DISCUSSION

Comparison between all physico-chemical parameters of the study soils is described in Figure. 1 to 16 revealing the general fertility status of the study soils in different areas and with parameters at different soil depths. The findings indicated that the soils ranged from clayey to clay loam and there was no systematic pattern for the distribution of soil separates in the two soil depths. The reactions of the soils as depicted from the pH values were alkaline in nature. The soils were poor in organic matter probably associated with sandy almost equal proportions of the soil separates at the surface. The soils were calcareous in nature predominated by high contents of CaCO3 and driven by high pH levels. These findings suggest that the study soils have adequate quantities of N, P, K, S, Mg, Ca, and Mo because of high pH values. However, their availability for plant uptake might be very variable because of ionic competition and other possible transformations of these elements in soils. For example, it is more likely in these soils, the high Ca contents will suppress B concentration and inhibit Mg uptake by the plant. In addition, the pH levels of the study soils suggest that P is more likely to be precipitated by carbonates of Ca and Mo and become restricted for readily plant uptake. Further to that, the pH levels obtained for the study soils in both soil depths vindicate the low quantities of soluble Fe, Mn, Cu and Zn obtained in these soils.

Moreover, the solubility of these micronutrients (Fe, Mn, Cu and Zn) in the study soils did not follow a definite pattern but, generally, relatively higher quantities were recorded in the surface soils. This is highly determined by the reaction nature of the surface soil which might have been contributed by the decomposition of organic matter with time. In addition, acid rains and root exudates (containing $Al_3^+$and H^+) also

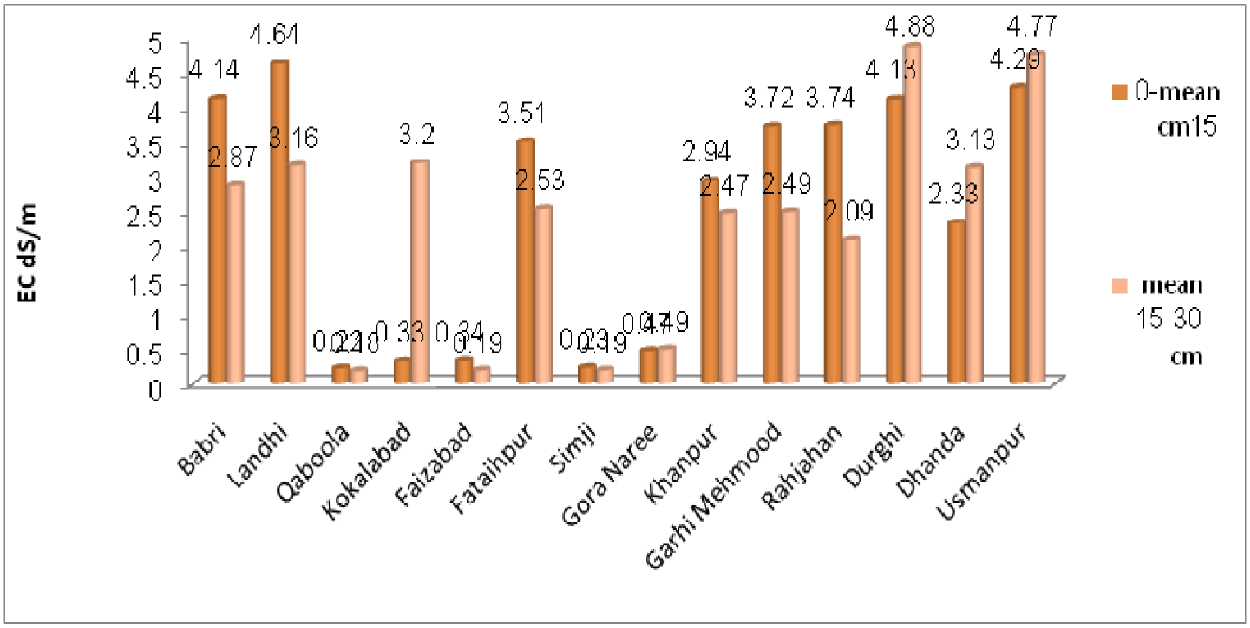

Figure 1: The mean values of Ec (dS m^{-1}) at different soil depth. Category of EC based on Jackson (1985): Non-saline = < 0-2 dS m^{-1}; strongly saline = < 0-2 dSm^{-1}; slightly saline = < 2-4 dSm^{-1}; very strongly saline = < 0-2 dSm^{-1}; moderately saline = < 4-8 dSm^{-}

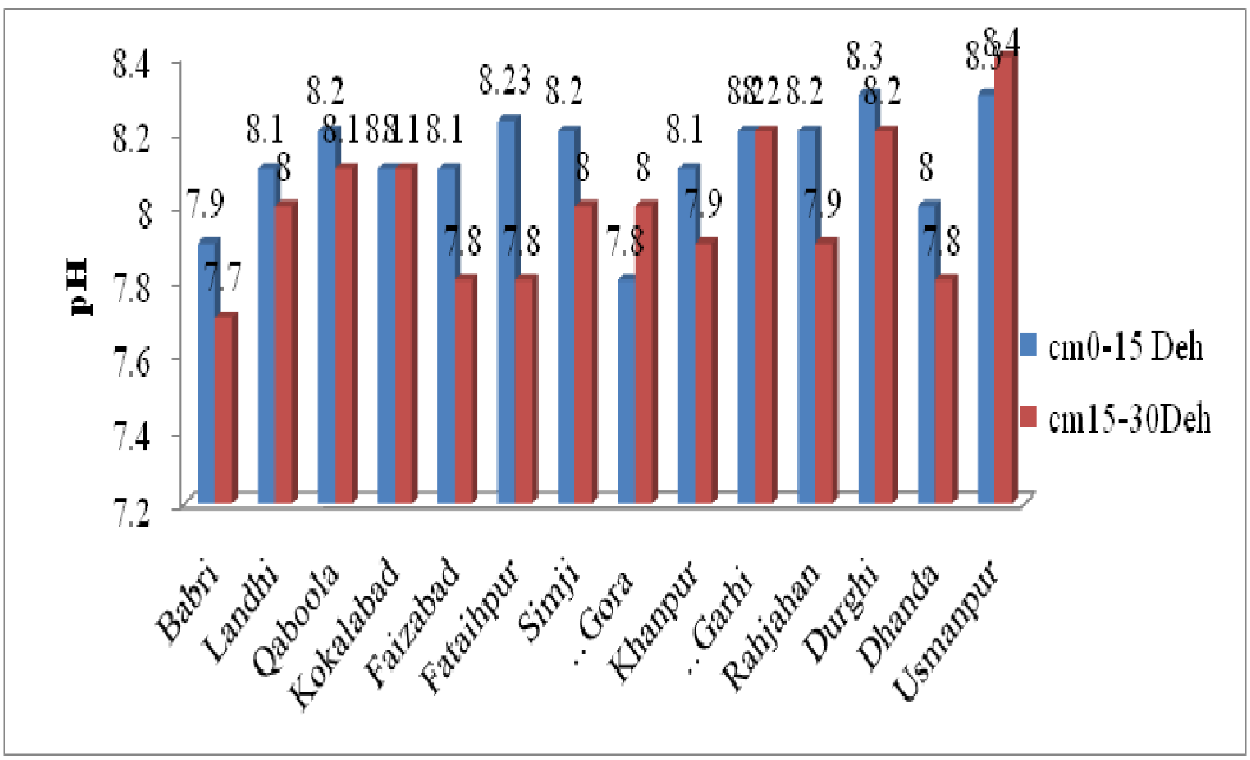

Figure 2: The mean values of soil pH in different soil depths Category of pH based on Cheema et al. (1991): Neutral = 7.0; Strongly alkaline = 8.1- 9.0;Slightly alkaline = 7.1- 7.5; Very strongly alkaline = > 9.1; Moderately alkaline = 7.6 - 8.

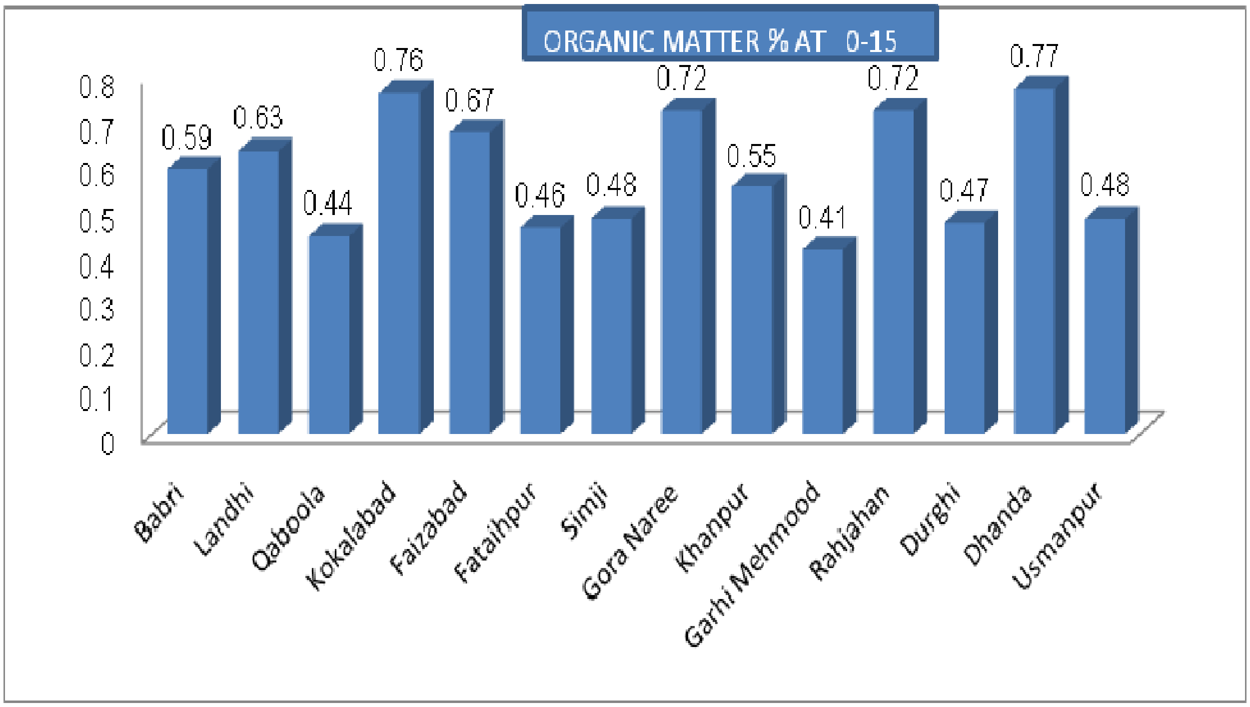

Figure 3: The mean values of O.M at the soil depth of 0-15 cm

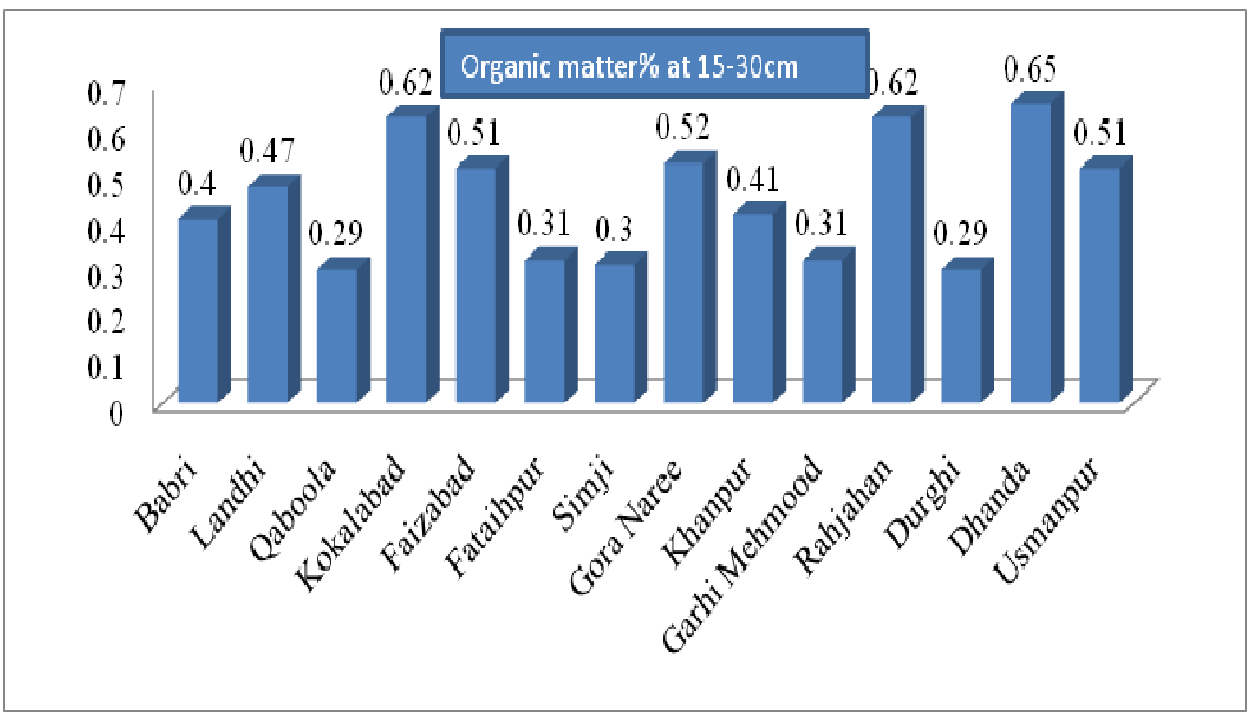

Figure 4: The mean values of O.M (%) at the soil depth of 15-30 cm Categoryof O.M (%) based on Rashid et al. (1988): Low = < 0.86 %; Medium = 0.86-1.29 %; High = > 0.86 %. 1.29%

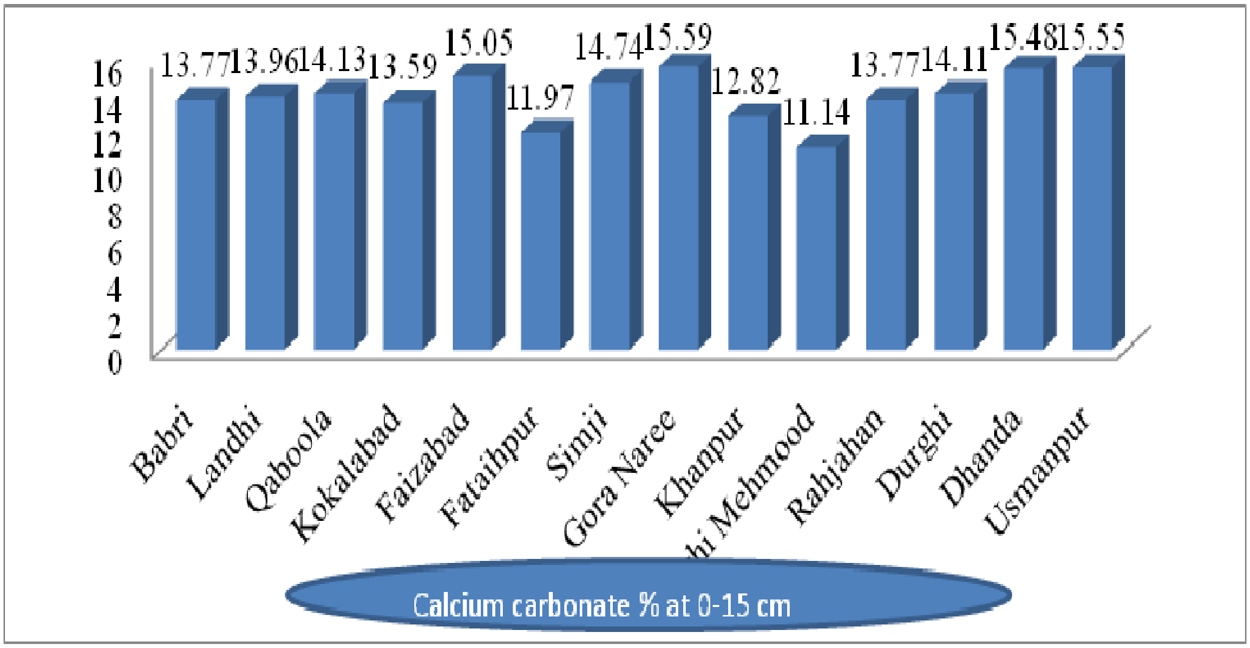

Figure 5: The mean values of CaCO3 (%) at the soil depth of 0-15 cm

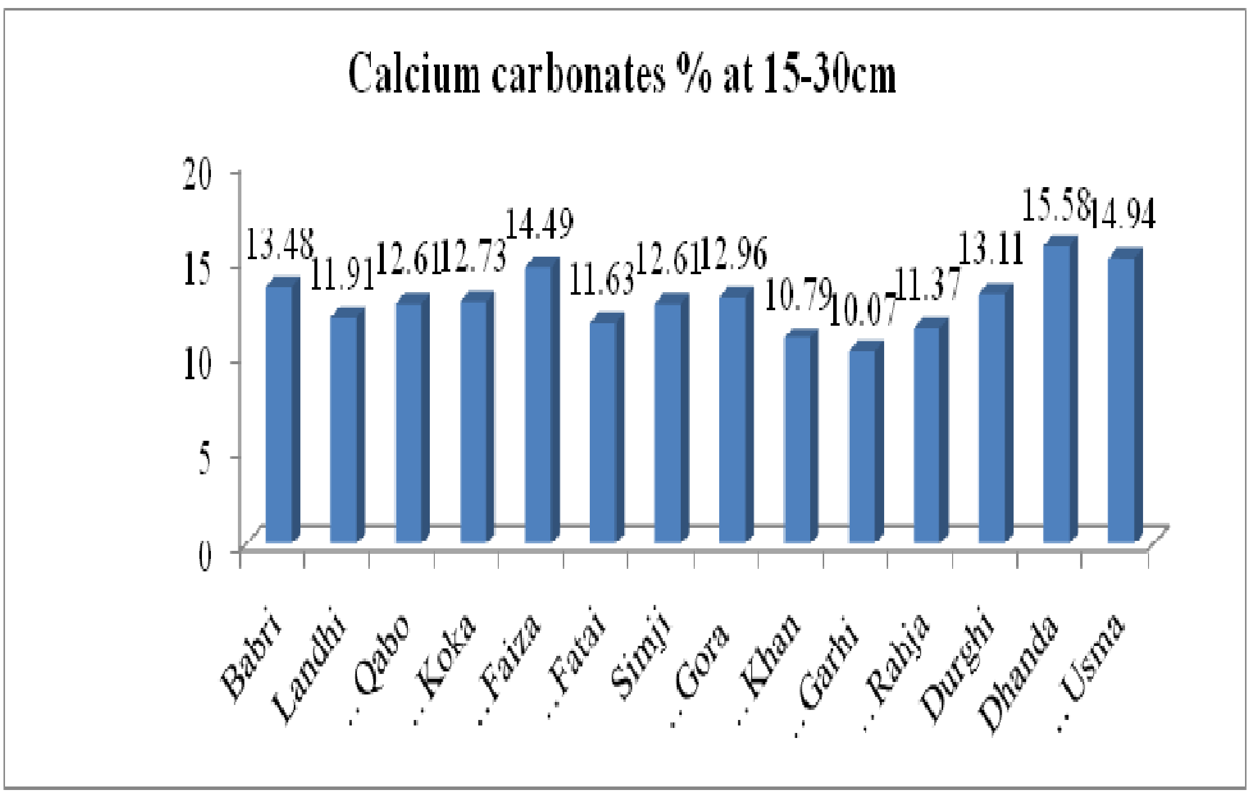

Figure 6: The mean values of $CaCO_3$ (%) at the soil depth of 15-30 cm Category of CaCO3 (%) based on Rashid et al. (1988): Low = < 0-7 %; Medium = 7-14 %; High = > 14 %

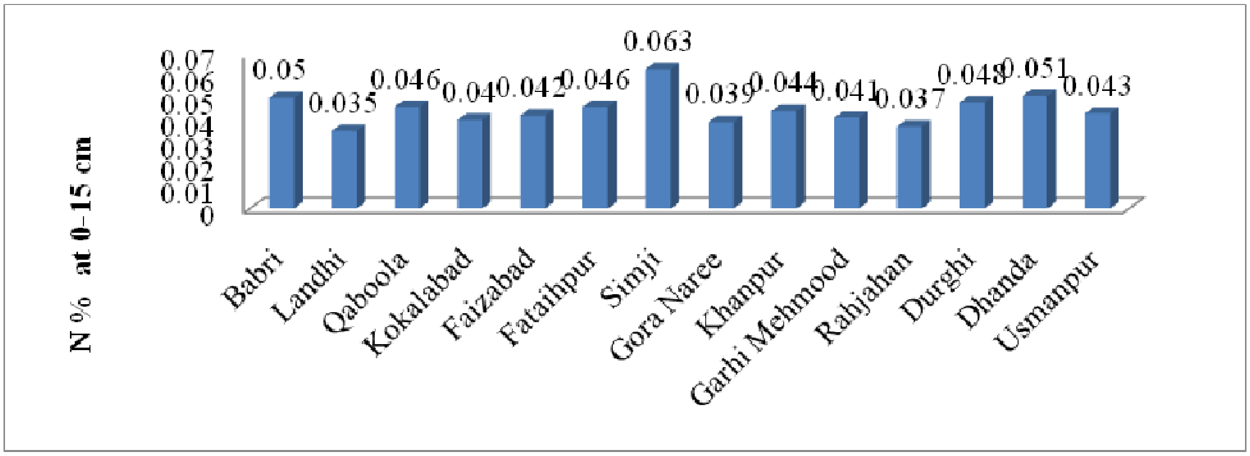

Figure 7: The mean values of total N (%) at the soil depth of 0-15 cm

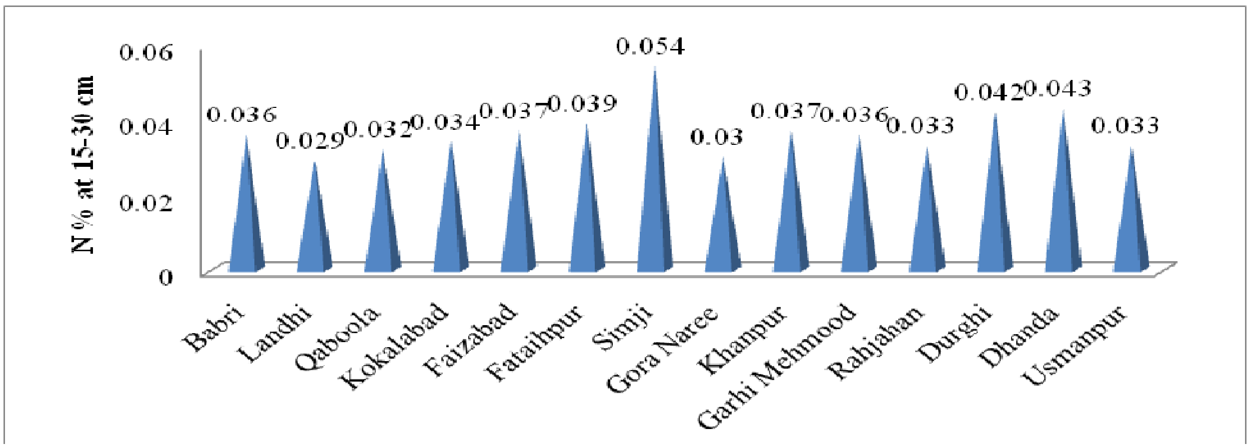

Figure 8: The mean values of total N (%) at the soil depth of 15-30 cm Category of total N (%) based on Melherb (1963): very low = < 0.05 %; Medium = 0.05-0.1 %; Fairly fertile = 0.1- 0.2 %; Fertile = > 0.2 %

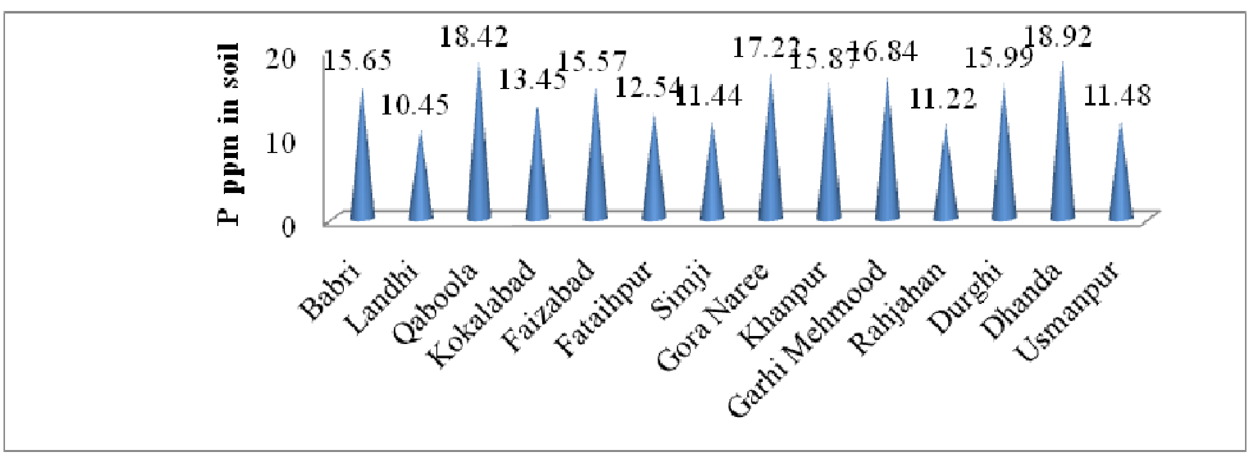

Figure 9: The mean values of available P (ppm) at the soil depth of 0-15 cm

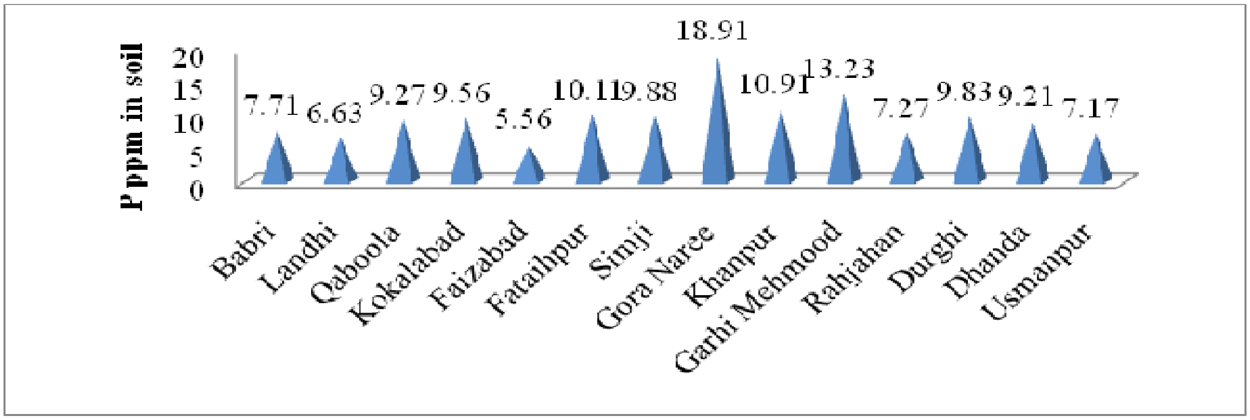

Figure 10: The mean values of available P (ppm) at the soil depth of 15 -30 cm Category of soil available P (ppm) based on Olsen et al. (1954): Low = 0-8 ppm; Medium = 8-15 ppm; High = > 15 ppm

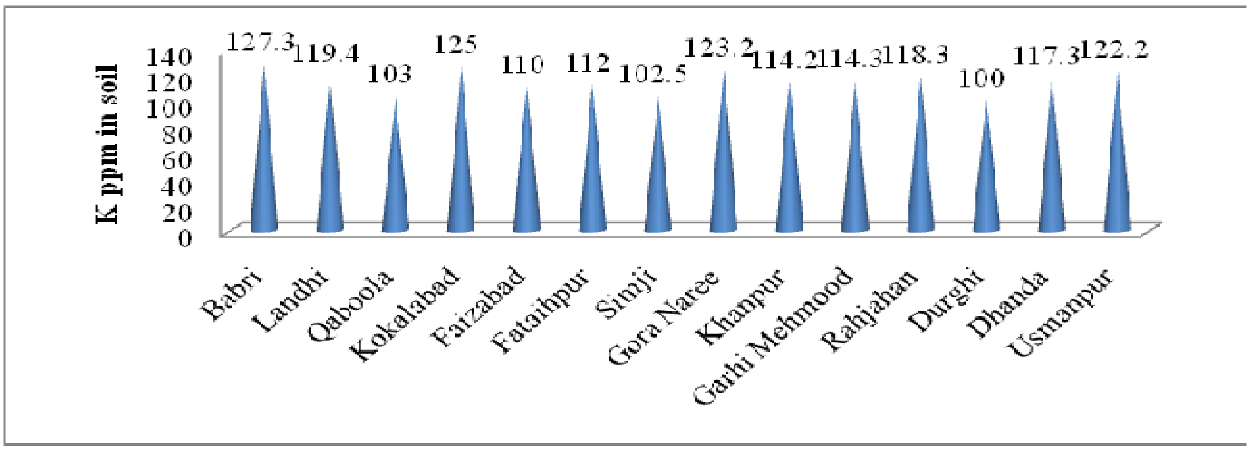

Figure 11: The mean values of exchangeable K (ppm) at the soil depth of 0-15 cm

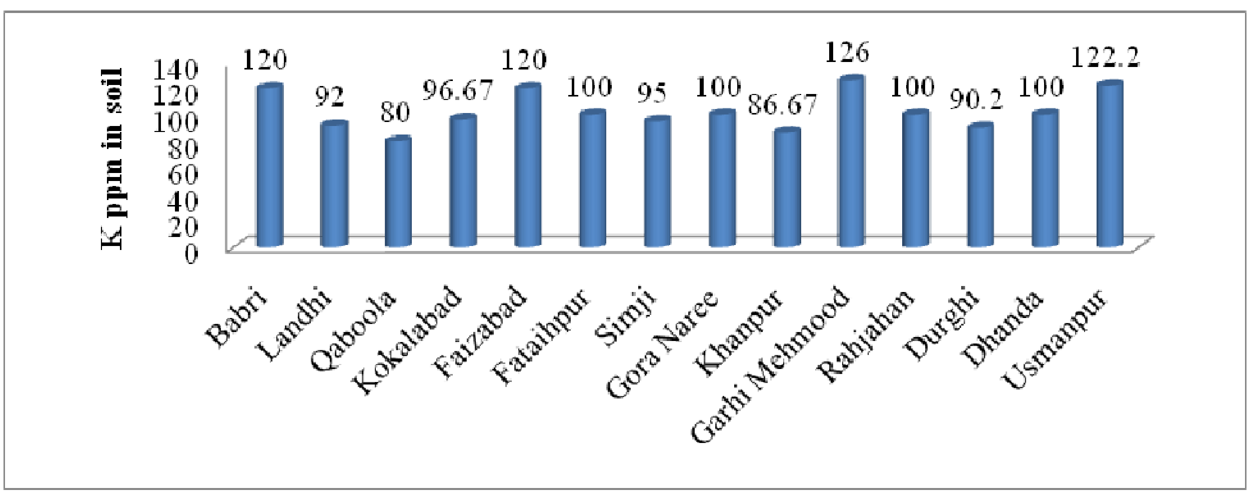

Figure 12: The mean values of available K (ppm) at the soil depth of 15-30 cm Category of exchangeable K (ppm) based on Soltanpour and Schwab (1977): Low = < 60 ppm; Medium = 60-120 ppm; High = >120 ppm

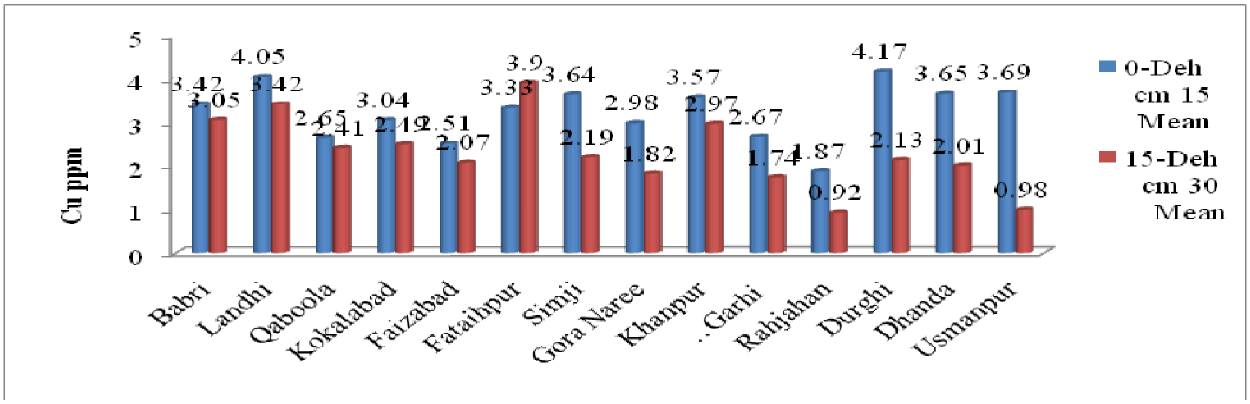

Figure 13: The mean values of extractable Cu (ppm) in different soil depths Category of soil extractable Cu (ppm) based on Soltanpour and Schwab (1977): Low = < 0. 5 ppm; High = > 0.5 ppm

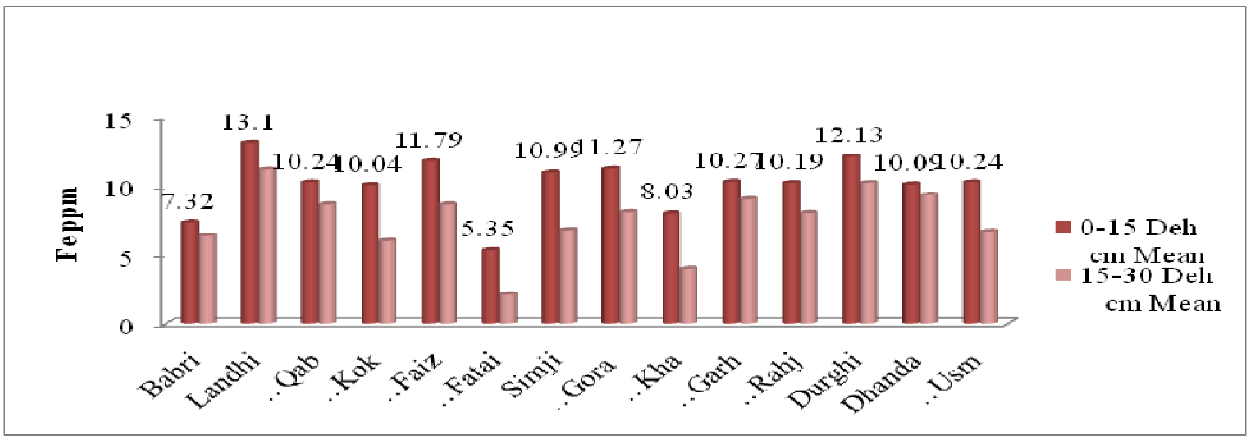

Figure 14: The mean values of soil extractable Fe (ppm) in different soil depths Category of soil extractable Fe (ppm) based on Lindsay and Norvell (1978): Low = < 2.0 ppm; Medium = 2-4 ppm; High = > 4.0 ppm

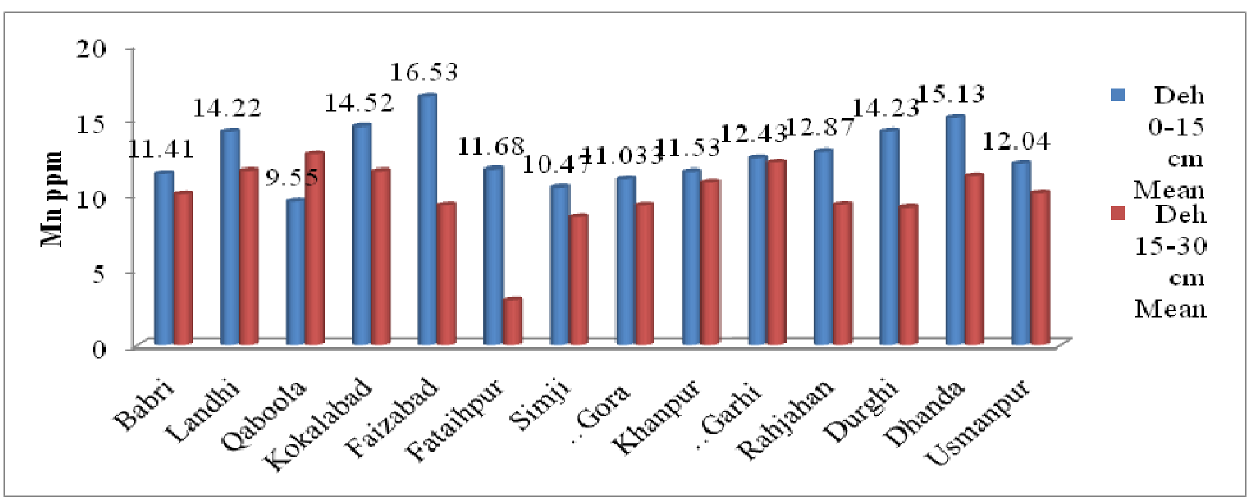

Figure 15: The mean values of soil extractable Mn (ppm) in different soil depths Category of soil extractable Mn (ppm) based on Soltanpour and Schwab (1977): Low = < 1.8 ppm; High = > 1.8 ppm

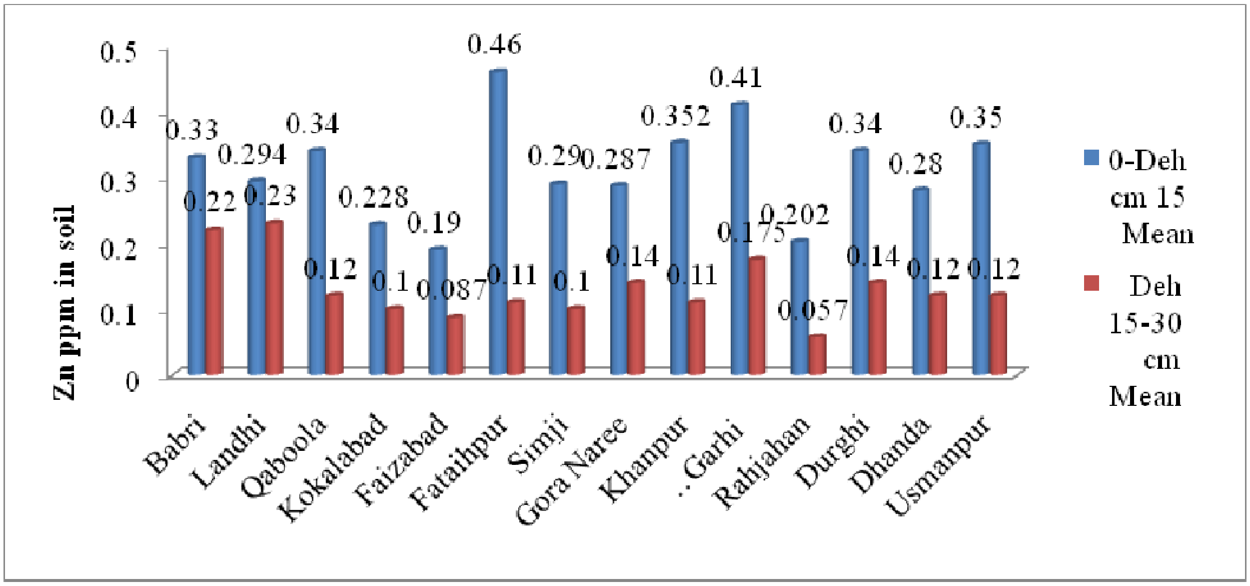

Figure 16: The mean values of soil extractable Zn (ppm) in different soil depths Category of soil extractable Mn (ppm) based on Lindsay and Norvell (1978): Low = < 0.8 ppm; High = > 0.8 ppm

induce some acidity which increase in the solubility of the micronutrients in the soil except Mo, which is favoured by high pH levels. Nazif et al. (2006) reported that most sandy soils are often deficient in micronutrients while clayey soils are not comparatively to be low in plant available micronutrients. The findings of this study suggest that the availability of macronutrients and solubility of micronutrients in soils is highly determined by pH and to lesser extent by the soil depths of 0 – 30 cm. This is the mostly explored soil depth of the roots of most annual and biannual crops and the nutrients are prone to depletion at this soil depth. However, soil depths exceeding the coverage of this study. The inconsistent variation of the quantities of nutrients with different quantities of the nutrients could be obtained in soil depths is also reported by Qayyum et al. (1987).

The findings of this study indicated that Mn was relatively higher in all soils in both soil depths and these findings are similar to those of Rashid et al. (1988). The levels of Fe were generally higher at 0-15 cm than in the 15-30 cm soils and these findings are in agreement with those reported by Khanzada (1970). On the other hand, Kashmiri (2001) and Malik (2001) reported that the contents of N and P in soils decreased successively with the increase in soil depth. In this regard the extent of the sandy soils in Pakistan is nearly 6 % that is 1.6 million acres of the total cultivated area in canal commended areas. Oad et al. (2003) studied the fertility status of the soils and described that all soil series were heavy in texture, non-saline and low in organic matter, slightly to moderately alkaline, moderately calcareous in nature; total N, Olsen P and extracable- K were higher in the upper depth soil horizons and decreased linearly as the depths of soil profile increased. The general observation revealed that in many studies conducted in Sindh and elsewhere (Memon et al., 1989; Anonymous, 1998; Rashid et al., 2006; Dursun et al., 2010) the soils were not deficient in Cu, Fe and Mn but Zn was low. In addition, Memon et al. (1989) observed that 44 % of the soils of Badin district were deficient in Zn. This work is also in agreement with the results of Zia et al. (2006) who observed Zn deficiency in soils of with orchards in Balochistan (43 %) and Sindh (90 %).

REFERENCES

Alloway BJ (1990). “Cadmium”. In Heavy Metals in Soils, Alloway BJ (ed.), pp. 100-121, Blackie and Son, Glasgow, Scotland.

Anonymous (1998). Micronutrients in Agriculture. Pakistan Perspective. National Fertilizer Development Centre Islamabad, Pakistan.

Bouyoucos GH (1962). A recalibration of the hydrometer method for making mechanical analysis of soils. Agron. J. 43: 434-438.

Brady NC, Weil RR (2008). The Nature and Properties of Soils. 14th Edition. Pearson Prentice-Hall Inc., Upper Saddle River, New Jersey, USA. p. 978.

Brady NC, Weil RR (2002). The Nature and Properties of Soils. 7th Ed. Prentice Hall, New Jersey. p. 296.

Bremner JM (1965). Total nitrogen. In Black CA et al. (ed.). Methods of Soil Analysis. Part 2 1 sted. ASA, Madison, WI. Pages: 1149–1178.

Cheema SS, Dhaliwal BK, Sahota TS (1991). Theory and digest of agronomy, 1st ed. Kalyani Publishers, Daryaganj, New Delhi, India.

Chhabra G, Srivastava PC, Ghosh D, Agnihotri AK (1996).Crop Research-Hisar, 11(3): 296-303.

Devlin R (1982). Vegetable physiology. Cuarta edicion. Barcelona, Espana. Editorial omega S.A. 516.

Dursun A, Turan M, Ekinci M, Gunes A, Ataoglu N, Esringü A, Yildirim E (2010). Effects of boron fertilizer on tomato, pepper, and cucumber yields and chemical composition. Commun. in Soil Sci. Plant Anal., 41: 1576-1593.

Grotz N, Guerinot ML (2006). Molecular aspects of Cu, Fe and Zn homeostasis in plants. Biochem. Biophys. Acta, 1763: 595–608.

Jackson ML (1962). Soil Chemical Analysis. An Advanced Course. University of Wisconsin Madison, Wise. Pages: 47 – 88.

Jackson ML (1969). Soil Chemical Analysis. Constable Co. Ltd., London.

Jackson ML (1985). Soil Chemical Analysis. Prentice Hall Eaglewood Cliffs, New Jersey, USA. pp.163, 164, 183, 220-221.

Kashmiri NA (2001). Status of NPK in soil of Taluka Tandoallahyar. M.Sc. Thesis, Sindh Agriculture University Tandojam, Pakistan.

Kaya C, Higgs D (2002). Inter-relationships between zinc nutrition, growth parameters, and nutrient physiology in a hydroponically grown tomato cultivar. J. Plant Nutrit., 24(10): 1491-1503.

Khanzada SK (1970). Status of micronutrient elements of the soils of Agriculture Research M.Sc. Thesis Sindh Agriculture University Tandojam, Pakistan.

Knudsen D, Peterson GA, Pratt PF (1982). Lithium, sodium and potassium In Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties. Page AL (ed.). American Society of Agronomy, Madison, WI, USA. pp. 225-245.

Lindsay WL, Norvell WA (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Am. J. 42: 421–428.

Malik HA (2001). Status of N, P and K in soils of Dharejob farm in Taluka Pano Akil M.Sc. Thesis, Sindh Agriculture University Tandojam, Pakistan.

Melherb IDV (1953). Soil Fertility University Press, London, Oxford.

Muhammad Usman Memon (2005). Soil fertility Status of Taluka Hala, District Hyderabad. M.Sc. Thesis, Sindh Agriculture University Tandojam, Pakistan.

Memon KS, Puno HK, Memon SM (1989). Cooperative research programme on micronutrient status of Pakistan soils. Fifth Annual Report, Department of Soil. Science, Sindh Agriculture University Tandojam, Pakistan.

Murphy J, Riley JP (1962). A modified single solutionBrady NC, Weil RR (2008). The Nature and Properties of Soils. 14th Edition. Pearson Prentice-Hall Inc., Upper Saddle River, New Jersey, USA. p. 978

Nazif, WS Parveen, I Saleem (2006). Status of micronutrients in soil district Bhimber and their relationship with various physic-chemical properties. Journal of Agricultural and Biological Sciences.(1):35.

Oad FC, UK Gaimnani, HA Samo (2003). Fertility status of the soils around Tandojam, District Hyderabad, Sindh, Pakistan. Pak. J. Applied Sci. 3(3):173-177.

Olsen SR, CV Cole, FS Watanabe, LA Dean (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. U.S. Dept. Agric. Circ. 939, Washington D.C.

Qayyum FM, I Nizami, SR Khan (1987). Available micronutrients of beach mark soil in pothawar region.Proc.Natio.Semi. On micronutrients in soils and crops Pak.Dec.13-15.

Pathak P, SP Wani, RR Sudi (2011). Long-term effects of management systems on crop yield and soil physical properties of semi-arid tropics of Vertisols. Agricultural Sciences.2(4):435-442.

Rashid A, Memon KS (2002). Text Book of Soil Science. National Book Foundation, Islamabad, Pakistan.

Rashid A, Yaseen M, Ali MA, Ahmad Z, Ullah R (2006). Residual and cumulative effect of boron use in rice-wheat system in calcareous of Pakistan.18th World Congress of Soil Science July 9-15, Philadelphia, Pennsylvania, USA.

Rohheld V. Marchner H (1991). Function of Micronutrients in Plants. In: Mortredt JJ et al. (eds). pp. 297-328.

Smil V (2001). Enriching the earth: Fritz Haber, Carl Bosch, and the transformation of world food production. MIT Press, Cambridge, MA.

Soltanpour PN, Schwab AP (1977). Use of NH4 HCO3-DTPA soil test to evaluate elemental availability and toxicity. Comm. Soil. Sci. Plant Anal. 16:323-338.

Sultana N, Ikeda T, Kashem MA (2001). Effect of foliar spray of nutrient solutions on photosynthesis, dry matter accumulation and yield in seawater-stressed rice. Environ. Exp. Bot. 46: 129-140.

Zia MH, Ahmad R, Khaliq I, Ahmad A, Irshad M (2006). Micronutrients status and management in orchards soils: Appl. Aspects Soils Environ., 25(1): 6-16.