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Relationship of physico-chemical properties and macronutrients indexing at soils of Ghora Bari area district Thatta, Sindh, Pakistan

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Abstract

The field study was conducted to determine association of soil physico-chemical properties with plant available macronutrients in Taluka Ghora Bari district Thatta. A total of 100 soil samples were collected from different sites at 0-15 and 15-30 cm depths. The results showed that 66% were heavy in texture, while 34% were light textured. Soils were alkaline (82%), moderately saline (81%), highly calcareous (97%) in nature, and low (66%) in organic matter. Majority of soil samples (77%) were poor in total nitrogen, 51% were deficient in available phosphorus while exchangeable potassium was adequate. Clay correlated negatively with P and K and positively with N, while sand correlated positively with K. The effect of lime content on NPK was found negative, while soil pH was correlated negatively with P and K. Organic matter correlated highly significantly with N, P and K.

Keywords: Physico-chemical properties, NPK status, nutrients index Ghora Bari, Sindh

Introduction

The deficiency of nutrients has become major constraint to productivity and sustainability of soils. For the better growth of plants, amongst many other factors, thirteen essential elements are required to be present in soil in proper proportion and available form. Amongst these elements, nitrogen (N), phosphorus (P) and potassium (K) are categorized as macronutrients and are required in larger quantity than the other nutrients (Foth, 1984; Brady, 1990). The selection of proper rate of these plant nutrients is based on the knowledge of nutrient requirements of crop and nutrient supplying power of the soil. Results of physical and chemical properties are quality indicators which provide the information about capacity of soil to supply mineral nutrients.

Crop yield depends on the available nutrient status of the soil (Khan *et al*., 2009). It has been reported that almost 100% soils of Pakistan are deficient in N, 90% deficient in P, 20 to 40% deficient in K while organic matter is on average 0.5% only (Wahab, 1985; Rashid, 1996; Shah and Arshad, 2006; Perveen *et al.*, 2010; Saleem and Akhtar, 2011). The soil properties like clay, pH and lime contents are negatively correlated with mineral nutrients (Ali *et al.*, 2000) and may cause to decrease the availability of plant nutrients by fixing or formation of insoluble compounds (Chaudhry *et al.*, 2012). The soils of coastal belt are degrading gradually, resulting drastic decline in average yield of major crops.

Efforts are being made to increase food and fibre requirements of increasing population of country. However, for better utilization of inputs, characteristics and properties of soil must be known. Regular inspection of soil nutrient status plays an important role in diagnosing nutrient deficiencies and sometimes toxicities that can adversely affect growth and crop yield (Memon *et al.*, 2010). Hence, the situation invites to review the nature and extent of problems in soils and work out suggestions for improved nutrient management practices for sustainable crop productivity. The knowledge of soils for their nutrients supplying capacity helps in deciding the appropriate cultural practices and selection of proper rate of nutrients to supply. Therefore this study was planned to investigate the nutrients availability status and their relationship with soil properties.

Material and Methods

Total one hundred soil samples were collected from 50 different cultivated and fallow sites at 0-15 and 15-30 cm depths from Taluka Ghora Bari (24° 23' 38.81" N and 67° 49' 33.31" E) district Thatta (Figure 1). Soil samples were collected from the areas where the farm yard manure and NPK fertilizers were not applied recently. Collected samples were air dried under shadow, ground and sieved through 2 mm sieve and stored in the plastic bags. Samples were analyzed for particle size distribution by Hydrometer method (Bouyoucos, 1936), EC and pH in 1:5 soil water extract (McLean, 1982), Lime content ($CaCO_3$) was determined by acid neutralization method of Soltanpour and

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Workman (1981), total organic matter was analyzed by Walkley-Black method (Jackson, 1969).

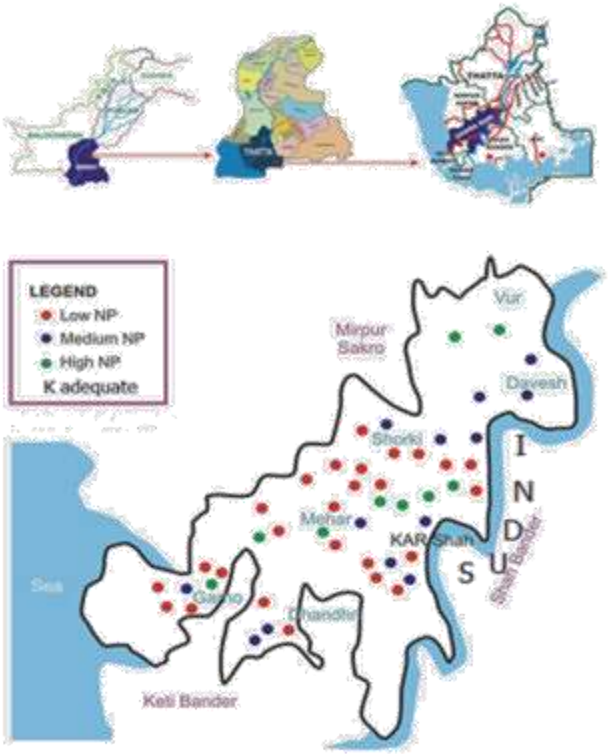

Figure 1: Mat Taluka Ghora bari showing sampling sites

Total nitrogen (%) by Kjedhal's apparatus (Jackson, 1969). Available phosphorus (mg kg^{-1}) by Olsen extractant sodium bicarbonate method (Olsen *et al*., 1954). Exchangeable potassium by the AB-DTPA extract method (Soltanpour and Schawab, 1977). The categorization of soil for pH, EC and lime content was carried out according to NMSU (2000) and soil texturel classes were indentified as suggested by Foth (1984). Nutrients index was calculated as formula proposed by Parker e*t al.* (1951).

Nutrients index (NI) = $((N_i x\ 1)+(N_m x2)+(N_h\ x3))/N_t$

N_i = Number of samples falling in low category of given nutrients

N_m = Number of samples falling in medium category of given nutrients

N_h = Number of samples falling in high category of given nutrients

N_t = Total number of samples analyzed in a given area

The data collected was subjected to descriptive means of minimum, maximum, mean, confidence intervals, standard deviation and coefficient of correlation (r) were analyzed by using SAS version 9.0 (SAS Institute Inc., NC, USA, 2003) system.

Results and discussion

Soil texture

The sand and clay contents showed significantly wide range of variability within samples at both 0-15 and 15-30 cm depths (Table 1). The clay content was more than silt and sand. The clay content was 18.9% higher in surface layer than subsurface soil. While sand particles were 31.95% high in subsurface soil. From eight identified textural classes, 66% soil samples were heavy and 34% samples were light textured (Table 2). The results were in accordance with previous studies of Mari *et al*. (2006) and Panhwar *et al.* (2001) who reported that soils of Dadu and Nawab Shah districts of Sind were heavy in soil texture. Tagar and Bhatti (1996) stated that clay, silt loam and silty clay are dominant soil texture classes in Indus delta Thatta and Badin districts.

pH, EC and lime content

Table 1 showed that EC and lime content had significantly wide range of variability within samples at both depths (0-15 and 15-30 cm). The pH of 82% soil samples was slightly alkaline to moderately alkaline (Table 3). The high soil pH values indicated deficiency of plant available P and K. The EC 81% samples was low to moderately saline (Table 4). Lime content of 3% soil samples was slightly calcareous, 68% were calcareous and 29% were strongly calcareous at both soil depths (Table 5). The lime content decreased with depth and found as a major factor for lowering P and K availability. This may be due to the co-precipitation of P and K with carbonates or formation of insoluble compounds also reported by Ali *et al.*, (2000). The previous study work carried out by Memon *et al.*, 1985, Panhwar *et al.*, 2001 and Mari *et al*., 2006 stated that soils of Sindh province are alkaline, moderately to strongly saline and calcareous in nature.

Organic matter

The soil organic matter varied among sites and depth wise (Table 1). The soil indexed value (1.42) revealed that soil was generally low in organic matter. The data in Table 6 further stated that 66% soil samples were poor, 26% were satisfactory and 8% were adequate at both soil depths. The previous study work also indicated that soil organic matter content of district Thatta was ranged from 0.08% to 1.89% at both depths with mean values of 1.13% in 0-15 cm and 0.53% in 15-45 cm depths (Memon *et al.*, 1985). Panhwar *et al.* (2001) reported that soils of Dadu district of Sind were poor in organic matter ranging from 0.50-1.00% in surface and 0.30 to 0.73% in subsurface soils. The low organic matter in area may be due to meager return of organic residues to the soil and climatic conditions which

Table 1: Analysis of variance, range, mean and standard deviation of soil physico-chemical properties for two depths

Soil Property	0-15 cm			15-30 cm		
	Range	Mean	SD	Range	Mean	SD
Sand (%)	1.0 - 61.5	20.9 b	17.4	1.0 - 75.5	27.6 a	22.51
Silt (%)	10.5 - 55.0	27.47	13.82	3.5 - 59.0	28.83	10.11
Clay (%)	22.5 - 84.0	51.5 a	15.43	18.0 - 77.5	43.5 b	16.13
pH (1:5)	7.5 - 9.2	8.12	0.38	7.7 - 9.1	8.23	0.31
EC (1:5) dS m^{-1}	0.15 -14.89	2.0 a	3.32	0.1 - 5.0	0.94 b	1.22
Lime (%)	10.0 - 19.7	14.7 a	2.67	6.6 - 17.2	13.0 b	2.15
OM (%)	0.12 - 2.89	0.92 a	0.56	0.13 - 1.52	0.52 b	0.31
N (%)	0.007 -0.145	0.047 a	0.029	0.006 - 0.08	0.028 b	0.017
P (mgkg$^{-1)}$	1.89 - 30.52	11.6 a	7.32	1.2 - 20.2	6.33 b	4.25
K (meq100g$^{-1)}$	0.36 - 1.9	0.88 a	0.37	0.28 - 1.51	0.63 b	0.26

Means within columns followed by different letters are significantly different at 0.05 probability, SD = Standard deviation, EC = Electrical conductivity of salts, OM = Organic matter , N = nitrogen, P = Phosphorus, K = Potassium

Table 2: Soil textural classification of soil

Textural Class	No. of soil sample		Percent soil sample	
	0 - 15 cm	15 - 30 cm	0 - 15 cm	15-30 cm
Clay	33	21	66	42
Clay Loam	06	07	12	14
Sandy clay loam	05	08	10	16
Sandy clay	01	02	02	04
Silty clay	03	07	06	14
Loam	01	01	02	02
Silty clay loam	01	03	02	06
Sandy loam	--	01	--	02
Total	50	50	100	100

Table 3: Categorization of Taluka Ghora bari soils on basis of pH (1:5)

Category	pH Scale	No. of soil samples		Percent soil samples	
		0 - 15 cm	15 -30 cm	0 - 15 cm	15-30 cm
Neutral	7.00				
Very slightly alkaline	7.00 – 7.50	03	-	06	-
Slightly alkaline	7.50 – 8.00	23	13	46	26
Moderately alkaline	8.00 – 8.50	19	30	38	60
Strongly alkaline	8.50 – 10.50	05	07	10	14
Total		50	50	100	100

Table 4: Categorization of Taluka Ghora bari soils on the basis of EC (1:5)

Category	EC Scale (dSm^{-1})	No. of soil samples		Percent soil samples	
		0 - 15 cm	15 - 30 cm	0 - 15 cm	15-30 cm
Non- Saline	0- 02	05	05	10	10
Low Saline	02- 04	10	10	20	20
Moderate Saline	04 – 08	33	35	66	70
Highly Saline	08 – 16	02	--	04	--
Severe saline	≥ 16	--	--	--	--
Total		50	50	100	100

Table 5: Categorization of Taluka Ghora bari soils on the basis of lime content

Category	Lime content scale (%)	No. of soil samples		Percent soil sample	
		0 - 15 cm	15-30 cm	0-15 cm	15-30 cm
Non-calcareous	≤ 7.0	--	--	--	--
Slightly calcareous	7.0 – 10	01	02	02	04
Calcareous	10-15	30	38	60	76
Strongly calcareous	≥ 15	19	10	38	20
Total		24	24	100	100

Table 6: Soil available nutrients index

Available nutrient	Soil nutrients index categories and values			Nutrients index
	Poor (<1.5)	Satisfactory (1.5-2.5)	Adequate (>2.5)	
Organic matter (%)	66	26	8	1.42
Nitrogen (%)	77	19	4	1.27
Phosphorus ($mgkg^{-1}$)	60	31	9	1.49
Potassium ($meq100g^{-1}$)	--	2	98	2.98

are conducive to rapid mineralization. Good tilth is the first feature of good soil management. Heavy textured soils have high water holding capacity and after drying are very difficult to plough because of their hardness and compaction. Ali *et al.* (2000) reported that maintenance of organic matter encourages granulation, which is an important consideration of good tilth.

N P and K status and indexation

Majority of soil samples (77%) were poor, while the 19% medium and 4% were satisfactory. The nutrients index values indicated that soil were poor in available nitrogen (Table 6). Available Olsen-P (Table 1) content of 60% soil samples was poor, while in 31% was medium and in 9% it was in satisfactory range. The index values in Table 6 indicated that soil was poor in available phosphorus. Soil exchangeable potassium content in surface soil was high and in subsurface soil 2% soil samples were medium and 98% were high. Indexing values (2.98) suggested that soil K status was adequate (Table 6).

N, P and exchangeable K remained higher by 68, 81 and 30%, respectively, in surface soil as compared to subsurface soil depth. The previous studied revealed that soils of Pakistan are generally low in N and 90% are deficient in P and 90% are adequate in K (Sadiq, 1985; Memon *et al.,* 1992; Perveen *et al.*, 2010; Saleem and Akhtar, 2011). Though the K is adequate in our soils but K deficiency also occurred in specific crop genotype and soil under continuously cultivation (Rashid, 1996). The previous work indicated that nutrient index values were poor in respect to organic matter, N and P, while satisfactory for K (Perveen *et al.*, 2010; Khalid *et al.*, 2012).

Coefficient of correlation

The clay content significantly negatively correlated with P K sand vs NP. Clay with N and sand with K were significantly positively correlated (Table 7). The increase of availability of nitrogen by clay is may be due oxidation of fixed ammonium- N to nitrate- N, and readily moves with soil water to root surface. The major difference between the N and P availability is that N available forms are relatively stable ions, while P available forms reacts quickly with other ions in soil solution to become less soluble. The K fixation on clay conserves K that might otherwise lost by leaching Foth (1982).

Table 7: Correlation between NPK and physico- chemical properties

Soil property	Coefficient of correlation (r)		
	N	P	K
Clay (%)	0.3	-0.32*	-0.28
Sand (%)	-0.39**	-0.29	0.28
Silt (%)	0.10	0.21	0.13
pH	0.05	-0.16	-0.12
EC (dSm^{-1})	0.39**	0.11	0.10
OM (%)	0.99**	0.32*	0.37**
Lime (%)	-0.14	-0.29	-0.15
N (%)	--	0.24	0.37**
P ($mgkg^{-1}$)	0.24	--	0.036

*,** significantly different at 0.05 and 0.01% levels of probability, respectively

The soil pH was positively correlated with N and negatively correlated with P and exchangeable K, while lime content showed the negative relationship with NP and K. The negative response suggested the low availability and fixing of plant nutrients. More (1978) reported that nutrient fixing capacity was positively correlated with soil clay, pH and calcium carbonate ($CaCO_3$). The role of organic matter for the nutrient availability was remained high than other soil physico-chemical properties. The organic matter was highly positively and significantly associated with NPK and responsible for increased availability of N (98%), P (10.02%) and K (13.69%). The high coefficient of correlation associated with nutrients suggested that response was high, whereas a small coefficient of correlation indicated that response was small for increasing or decreasing of nutrient availability (Table 7).

Conclusion

It was concluded that soils of Taluka Ghora Bari district Thatta were heavy in texture, alkaline in soil reaction, contain the low amount of organic matter and highly calcareous in nature. The most soils were poor in N, low to medium in P and adequate in exchangeable K. For obtaining high yield production the soils should be supplemented with N and P while, the K may be applied to higher K demanding crops like sugarcane, banana, corn and orchard crops etc. Farm yard manure, green manure and crop residues may be added in soil regularly and proper crop rotation be followed to maintain the soil fertility status.

References

Ali, M., M.S. Sarir, M.U. Shirazi, S.M. Alam and R. Ansari. 2000. Phosphorus mineralization in some soil series of Peshawar Valley. *Pakistan Journal of Soil Science* 18(14): 13-18.

Bhati, M. 2011. Potash need assessment and use experience in Khyber Pakhtunkhawa (KPK). *Soil & Environment* 30(1): 27-35.

Bouyoucos, G.J. 1936. Directions for making mechanical analysis of soils by the hydrometer method. *Soil Science* 4: 225-228.

Chaudhary, P.R., D.V. Ahire and V.D. Ahire. 2012. Correlation between physico-chemical properties and available nutrients in sandy loam soils of Haridwar. *Journal Chemical Biological and Physiological Science* 2(3): 1493-1500.

Foth, H.D. 1982. *Fundamentals of Soil Science*. 6th Edition John Wiley & Sons, Inc. USA.

Jackson, M.L. 1962. *Soil Chemical analysis*. Prentice Hall, Inc. Englewood Cliffs, New York USA.

Jackson, M.L. 1969. Soil Chemical Analysis. Advanced Course. 2nd Ed. Madison, WI.

Khalid, R., T. Mahmood, R. Bibi, M.T. Siddique, S. Ali and S. Yaqub-Naz. 2012. Distribution and indexation of plant available nutrients of rainfed calcareous soils of Pakistan. *Soil and Environment* 31(2): 146-151.

Khan, A., M.T. Jan, K.B. Marwat and M. Arif. 2009. Organic and inorganic nitrogen treatment effects on plant and yield attributes of maize in a different tillage systems. *Pakistan Journal of Botany* 41(1): 99-108.

Malherbe, De V. 1963. Soil Fertility. 5th Ed. Oxford University Press, Cape Town, South Africa.

Mari, A.H., R.N. Panhwar, G.M. Kaloi, M. Chohan, A.A.Y. Zai, M.A. Brohi and M.A. Bhutto. 2006. Assessing zinc status of sugarcane intaluka Nawabshah through soil and plant analysis. *Journal of Applied Science* 6(1): 206-210.

McLean, E.O. 1982. Soil pH and lime requirement. p. 199-224. *In:* Chemical and Microbiological Properties. Methods of Soil Analysis. Part 2, 2nd Ed. In series, American Society of Agronomy, Madison WI, USA.

Memon, K.S. 1985. Phosphorus requirement of Pakistan soils. p. 105-112. *In:* Proceeding 12th International forum on soil taxonomy and Agro- technology transfer, October 9-23, 1985, Lahore, Pakistan.

Memon, N., K.S. Memon, R. Anwar, S. Ahmed and M. Nafees. 2010. Status and response to improve NPK fertilization practices in Banana. *Pakistan Journal of Botany* 42(4): 2369-2381.

More, S.D. 1978. P fixing capacity as influenced by soil characteristics of vertisols. *Journal Indian Society Soil Science* 26(4): 403-406.

Mujeeb, F., Rahamtullah, J. Akhtar and R. Ahmad. 2010. Integration of organic and inorganic P sources for improving P use efficiency in different soils. *Soil and Environment* 29(2): 122-127.

NMSU. 2000. NMSU Soil Test Interpretations Guide A-122 Electronic Distribution, New Mexico State University (NMSU) and the U.S. Department of Agriculture cooperating.aces.nmsu.edu/pubs/_a/a-122.html [Accessed on: 06/11/2011].

Olsen, S.R., C.V. Cole, F.S. Watnabe and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Department of Agriculture, Inc. 939p.

Panhwar, R.N., S.M. Memon and M. Chohan. 2001. To study chemical composition and Zinc status of soils of Dadu taluka. *Pakistan Journal of Ariculture, Agricultural Engineering and Vetnary Science* 17(1-2): 19-23.

Parker, F.W., W.L. Nelson, E. Winters and I.E. Miles. 1951. The broad interpretation and application of soil test information. *Agronomy Journal* 43: 105-112.

Perveen, S., Z. Malik and W. Nazif. 2010. Fertility status of vegetable growing areas of Peshawar, Pakistan. *Pakistan Journal of Botany* 42(3): 1871-1880.

Rashid, A. 1996. Soils: Basic concept and principles In Soil Science A. Rashid and KaziSulemanMemon. National Book Foundation Islamabad.10-12

Sadiq, M. 1985. Phosphorus requirement of Pakistan soils. p. 113-118. *In:* Proc. 12th International Forum on Soil Taxonomy and Agro-technology Transfer, October 9-23, Lahore, Pakistan.

Saleem, M.T. and E. Akhtar. 2011. CAN fertilizer in Pakistan – a boon or a bane. *Farming Out Look* 10(4): 4.

SAS Institute Inc. 2003. SAS for Windows. Version 9.0. SAS Institute, Cary, NC.

Sen, H.S. 2009. Nutrient management in coastal soils. Paper presented in SAARC Workshop on Nutrient Use Efficiency in Agriculture. Central Soil Salinity Research Institute, 9-11 September, Karnal, India.

Foth, H.D. 1984. *Fundamentals of Soil Science.* John Wliley and Sons, New York, New York, USA.

Rashid, A. 1996. Basic concepts and principles. p. 3-24. *In: Soil Science*. E. Bashir and R. Bantel (eds.). National Book Foundation, Islamabad, Pakistan.

Tagar, S. and A.U. Bhatti. 1996. Soil physical properties. *In: Soil Science*. E. Bashir and R. Bantel (eds.). National Book foundation, Islamabad. 250p

Wahab, A. 1985. Report on crop response to fertilizers and soil test data in Pakistan FAO/NFDC, Islamabad.

Shah, Z.H. and M. Arshad. 2006. Land degradation in Pakistan: A serious threat to environments and Economic sustainability. Available at: www.eco-web.com/edi/060715.html [Accessed on: 13/12/2012].

Soltanpour, P.N. 1985. Use of NH_4HCO_3- DTPA soil test to evaluate elemental availability and toxicity. *Communications in Soil Science and Plant Analysis* 16: 323-338.

Soltanpour, P.N. and A.P. Schawab. 1977. A new soil test for the simultaneous extraction of macro and micro nutrients in alkaline soil. *Communications in Soil Science and Plant Analysis* 8: 195-207.

Soltanpour, P.N. and S. Workman. 1981. Modification of the NH_4HCO_3- DTPA soil test to omit carbon black. *Communications in Soil Science Plant Analysis* 10: 1411-1420.