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Spatial Distribution of Macronutrients in Soils of Arid Tract of Punjab, India

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ABSTRACT

Surface soil samples from 208 sites were collected, analysed and classified to assess and map soil fertility status of Mansa district, Punjab. The soils are low in organic carbon content. It ranged from 0.02 to 0.40% with a mean value of 0.29%. The available phosphorus content of these soils varied from 1.8 to 59.6 kg ha^{-1} with a mean value of 18.46 kg ha^{-1}. The available potassium content of these soils is generally medium to high, and only 3% soil samples tested low in available K. It ranged from 67.2 to 851.2 kg ha^{-1} with a mean value of 291.15 kg ha^{-1}. The nutrient index w.r.t. available N, P, K were also calculated on block basis. Seven categories of soil fertility(w.r.t. available N, P & K), viz., Low-Low-Low (LLL), Low-Low-Medium (LLM), Low-Low-High (LLH), Low-Medium-Medium (LMM), Low-Medium-High (LMH), Low-High-Medium (LHM) and Low-High-High (LHH) were mapped. The present study revealed that there is wide variation in soil fertility status of soils developed on various land forms in Mansa district, but, by and large, the soils are low in available N, low to high in available P and medium to high in available K content.

Key Words: Macronutrients; Arid tract; India

INTRODUCTION

Soil fertility, compactability and erodibility are the elements of soil quality. Among these elements, the problem of decline in soil fertility endangers the maximum the growth in productivity (Katyal, 2003). Warren and Agnew (1988) described that of all the threats to sustainability, the threat due to soil fertility depletion is the most serious. Depending upon the cropping pattern, leaching, erosion etc., soil looses a considerable amount of nutrients every year. If cropping is continued over a period of time without nutrients being restored to the soil, its fertility will be reduced and crop yields will decline. Poor soil fertility conceives sparse plant cover, which promote erosion vulnerability. This happens because 90% of plant available N and S, 50-60% K, 25-30% P and almost 70% of micronutrients reside in organic matter (Stevenson, 1982).

Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximising crop yields. Soil fertility maps are meant for highlighting the nutrient needs, based on fertility status of soils (and adverse soil conditions which need improvement) to realise good crop yields. Obviously, a soil fertility map for a particular area can prove highly beneficial in guiding the farmers, manufacturers and planners (associated with fertilizer marketing and distribution) in ascertaining the requirement of various fertilizers in a season/year and making projections for increased requirement based on cropping pattern and intensity.

The Green Revolution ushered in the State of Punjab in 1968 has rendered the country self sufficient in food grains and enabled us to pursue modernisation efforts with a measure of confidence. Thirty five years later, we are now beginning to be aware of the limitations of the single minded approach towards intensive resource use without adequate consideration for its wider environmental ramifications. By and large the inherent nutrient status of Punjab soils is low and the finite nutrient resources of these soils have been exhausted at a faster rate since the ushering of the green revolution. High intensity of cropping has resulted in the appearance of macro and micro nutrient deficiencies. In the present study, an attempt has been made to evaluate the soil fertility of Mansa district in arid tract of Punjab, India.

Study area. The study area is a part of Indo-Gangetic alluvial plain located in the arid tract of Punjab, India. The western Himalayas in the north and the Thar desert in the south and southwest mainly determine the climatic conditions. The area is believed to have been formed from the alluvial deposits of the river Satluj and Ghaggar and to some extent due to aeolian activity. It is a level plain with few scattered dunes and old filled up channels within which the great rivers have occasionally shifted their beds. The soils of the area are light to medium textured and have aridic (torric) moisture regime and hyperthermic soil temperature regime.

MATERIALS AND METHODS

To evaluate the soil fertility status of Mansa district a systematic survey was carried out. Surface (0-15 cm depth) soil samples were collected from 208 sites following the standard procedures of soil sample collection. The location of soil sampling sites was marked on the base map on 1:50,000 scale. The soil samples were processed and analysed for pH, electrical conductivity, organic carbon (Walkley & Black, 1934), available phosphorus (Olsen *et al.*, 1954) and available potassium (Jackson, 1967). The available N was estimated from organic carbon content of the soils.

The values of available nutrients (N, P, K) were transferred on the map after rating them low, medium and high (Table I) and finally the soil fertility maps for each block and district as a whole were prepared.

RESULTS AND DISCUSSION

Chemical characteristics of soils. The soils of the study area are alkaline in reaction (pH >7.0). The soil pH varied from 8.16 to 9.62. The distribution of samples in various pH ranges indicates that only 26% of total soil samples fall in the pH range from 8.00 to 8.75. The maximum number of soil samples (51%) fall in 8.75 to 9.00 pH range. However, it is stirtling to observe that a significant number of samples, i.e., 23% have pH values ranging from 9.00 to 9.75.

The total soluble salt content of these soils, expressed as electrical conductivity (EC), varied from 0.07 to 0.77 with mean value of 0.32 dS m^{-1}. The mean EC of soil samples indicates that EC of different blocks is of the order Jhunir > Bhikhi > Mansa > Sardulgarh > Budhlada. All the soil samples fall in the normal EC range indicating that salinity is not at all a problem in these soils. The lower values of electrical conductivity in these soils may be attributed to more macro pores, as majority of the soil samples in the area are light textured, resulting in free drainage conditions.

Organic matter content. The soils of Mansa district are low in organic carbon content. It ranged from 0.02 to 0.40% with a mean value of 0.29%. The distribution of soil samples with respect to organic carbon content indicates that about 19% soil samples had very low (<0.20 %) organic carbon. The blockwise perusal of the data indicates that only 12% soil samples from Budhlada block have very low organic carbon. In Sardulgarh block about 41% soil samples fall in the organic carbon range of 0.2 to 0.3%; whereas more than 50% soil samples from Jhunir, Mansa, Bhikhi and Budhlada blocks fall in the organic carbon range of 0.3 to 0.4%. The high temperature prevailing in the area is responsible for the rapid burning of organic matter, thus resulting in low organic carbon content of these soils. Since organic matter contents is an indicator of available nitrogen status of soils, thus the soils of the area are also dominantly low in respect of their available nitrogen (Table II)

Available phosphorus. The available phosphorus content of these soils varied from 1.8 to 59.6 kg ha^{-1} with a mean value of 18.46 kg ha^{-1}. In general, available P ranged from low to medium, but high values of available P are also found in some part of the area. About 45% soil samples tested low, 17% medium and 38% soil samples tested high in available P content. The data indicates that majority of the soil samples from Sardulgarh and Jhunir blocks are low in available P content; whereas, that of Bhikhi and Budhlada blocks are high in available P content. The high available P content is attributed to the regular application of phosphatic fertilizers and the immobile nature of phosphate ions in soils which must have resulted in accumulation of P in soils. In soils where available P content is high, there are much chances of Zn deficiency and it is extremely important to use requisite amount of phosphatic fertilizers.

Prior to 1985, the whole Mansa district was under Cotton-Wheat rotation, however after that large area in northern parts of the district covering Bhikhi and parts of Mansa and Budhlada blocks have come under Rice-Wheat cropping system. The Rice-Wheat cropping system requiring higher doses of nutrients, it has been observed that in these areas, there has been increase in available P due to build up. As in rice wheat cropping system, higher doses of nutrients are added, it has been observed that in the area, there has been an increase in available P due to its buildup over a period of time.

Available potassium. The available potassium content of these soils is generally medium to high, and only 3% soil samples tested low in available K. It ranged from 67.2 to 851.2 kg ha^{-1} with a mean value of 291.15 kg ha^{-1}. About 52 and 45% samples tested medium and high in available K, respectively. The available K content of soils of Sardulgarh, Bhikhi and Budhlada blocks is medium and that of Jhunir and Mansa is high. The higher content of available K is attributed to the prevalence of Illite - a potassium rich mineral in these soils (Kanwar, 1959). Moreover, as the ground waters of Mansa district have considerable amount of dissolved potassium, irrigation with such waters also results in higher amounts of available K in these soils (Patel *et al.*, 2000).

Soil test summary and nutrient indices. The nutrient index, i.e., a single index (weighted average) which indicates the overall fertility status of an area, was calculated (Parker *et al*., 1954) and presented in Table II. It shows that available N is practically low in all the blocks of Mansa district. The nutrient index for available P for the district is medium (1.92). It is low for Sardulgarh and Jhunir blocks, medium for Mansa and Budhlada blocks and high for Bhikhi block. The nutrient index for available K for Sardulgarh block is 1.16, being low, whereas it is high for all the other blocks.

Soil fertility assessment. Based on the criteria given in Table I, the soils of Mansa district have been characterised

Table I. Limits for Soil Test Values Used for Rating the Soils

Soil Constituent	*Low*	*Medium*	*High*
Organic Carbon (%)	<0.4	0.4-0.75	>0.75
Available Nitrogen (kg ha^{-1})	<271	271-543	>543
Available Phosphorus(kg ha^{-1})	<12.4	12.4-22.4	>22.4
Available Potassium(kg ha^{-1})	<113	113-280	>280

Table II. Soil Test Summary and Nutrient Indices

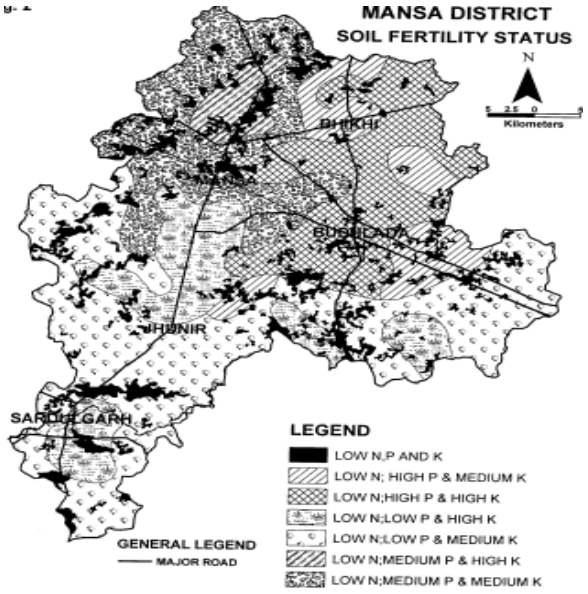
Soil Parameters	*% Sample*			*Nutrient Index*
	Low	**Medium**	**High**	
		Sardulgarh Block		
Avail. N	100.0	-	-	1.00
Avail. P	97.6	2.4	-	1.02
Avail. K	2.4	57.1	40.5	1.16
		Jhunir Block		
Avail. N	100.0	-	-	1.00
Avail. P	75.0	8.3	16.7	1.42
Avail. K	8.3	37.5	54.2	2.46
		Mansa Block		
Avail. N	100.0	-	-	1.00
Avail. P	25.8	45.2	29.0	2.02
Avail. K	-	38.7	61.3	2.61
		Bhikhi Block		
Avail. N	100.0	-	-	1.00
Avail. P	4.3	37.0	58.7	2.61
Avail. K	4.3	52.2	43.5	2.39
		Budhlada Block		
Avail. N	100.0	-	-	1.00
Avail. P	38.5	3.1	58.4	2.20
Avail. K	1.6	50.0	48.4	2.47
		District Mansa		
Avail. N	100.0	-	-	1.00
Avail. P	45.2	17.3	37.5	1.92
Avail. K	2.9	52.2	44.9	2.42

into seven soil fertility categories (w.r.t. available N, P & K), viz., Low-Low-Low (LLL), Low-Low-Medium (LLM), Low-Low-High (LLH), Low-Medium-Medium (LMM), Low-Medium-High (LMH), Low-High-Medium (LHM) and Low-High-High (LHH) The soil fertility map of the district (Fig. 1) has been prepared on 1: 50,000 scale. The soils of sand dune areas are low in their available N, P and K content. Most of the area of Sardulgarh and Mansa blocks is covered by LLM and LMM categories, respectively. In Jhunir block LLM and LLH are the dominant soil fertility categories, whereas these categories are absent in Bhikhi block. There is wide variation in soil fertility status of Budhlada block and a considerable area of this block is under LLM and LHH soil fertility categories.

CONCLUSION

The present study revealed that there is wide variation in soil fertility status of soils developed on various land forms in Mansa district, but, by and large, the soils are low in available N, low to high in available P and medium to high in available K content. The deficient nutrients have to be restored through chemical fertilizers and/or organic manures to maintain soil health. For efficient and sustainable crop production in these soils, a farming system that is both soil enriching and restoring needs to be developed.

Fig. 1. Map



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