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SPATIAL DISTRIBUTION OF SOIL AVAILABLE NUTRIENTS IN THE POTATO GROWING POCKETS OF HOSHIARPUR DISTRICT OF PUNJAB

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ABSTRACT: Soil samples of potato growing pockets of Hoshiarpur district of Punjab were collected and analysed for pH, OC and available NPK. The soil analysis data was fed into GIS software and spatial maps generated. The soils of the district in general, were slightly acidic to slightly alkaline in reaction. The pH of collected soil samples varied from 5.0 to 8.2 with a mean value of 6.8. About 90 per cent of the total area had pH less than 7.5, a situation considered much suitable for potato cultivation. The organic carbon ranged from low to medium (0.2 to 0.7%) with an average value of 0.4 per cent. Available nitrogen ranged from 186.3 to 355.6 kg/ ha with mean value of 242.5 kg/ ha and more than 88 per cent samples had available phosphorus greater than 20 ppm. None of the collected sample was deficient in available phosphorus, suggesting build-up of P fertilizers in these areas. In case of available soil potassium, 79, 19.2 and 2 per cent samples were found to be low, medium and high, respectively. After kriging, results showed that 30.5 and 18.8% area had high and very high phosphorus, respectively, but low in nitrogen and potassium. About 17.3 per cent area was medium in available nitrogen, very high in phosphorus but low in available potassium, while 12.8% area was medium in both available N and K but very high in P.

KEYWORDS: GIS, GPS, macronutrient, potato, soil available nutrients.

INTRODUCTION

Potato plays an important role in global food and nutritional security especially for the poor (Thiele *et al*., 2010**).** Potato is the fourth most important food crop in India after rice, wheat and maize with just 0.8% of gross cropped area (Scott and Suarez, 2011**;** 2012). In India, potato is a major vegetable crop and is being grown in a wide range of climatic conditions (Pandit and Chandran, 2011). Potato produces more dry matter (47.6 kg/ha/day) than any other food crop and therefore, requires higher amount of nutrient inputs (Kushwah and Singh, 2011). The imbalanced and indiscriminate use of fertilizers in intensive cropping system without adequate restorative practices may pose threats to sustainability of system, as high yielding varieties draw heavy amount of plant nutrients from soil and nutrient uptake often exceeds replenishment through fertilizers causing soil fertility deterioration at many places (Singh and Lal, 2011).

Punjab is an important potato growing state of India and contributes about 5% to national acreage and production. In Punjab, Hoshiarpur district accounts for about 20% of potato acreage and production and there are few pockets where majority of farmers are following potato based cropping systems. Potato is highly responsive to applied nutrients and in a system, receives maximum share of fertilizers. Farmers usually apply fertilizers without considering the information on soil fertility status and nutrient requirement of the crop, which leads to either nutrient toxicity or deficiency (Ray *et al*., 2000). In order to apply nutrients, based on soil fertility, it is necessary to know the location specific variability in nutrient supply

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to overcome the mismatch of fertilizer rates and crop nutrient demand (Dobermann and Cassman, 2002). Geographical Information Systems (GIS) and Ground Positioning System (GPS) are important to generate spatial maps of nutrients status, which help in good agricultural management systems and formulating plans for sustainable agricultural development (Sood *et al.*, 2009)**.** The present study was therefore, undertaken to assess the nutritional status of the soils of potato growing areas in Hoshiarpur district of Punjab and to map their spatial variability using GPS and GIS so as to refine fertilizer recommendations and promote site specific nutrient management.

MATERIALS AND METHODS

Soil samples and analysis

The potato growing pockets of Hoshiarpur district were demarcated based on the available information, ground truth data and classification of the IRS P6 AWiFS image. The classified potato area in IRS P6 AWiFS image was also taken as background to generate the sampling site map. During the study it was ensured that all the physiographic units/soils were represented in the sampling using the soil map of Punjab prepared on 1: 500,000 scale and published by the National Bureau of Soil Survey and Land Use Planning, Nagpur. Representative soil samples from 0-15 cm depth of potato fields were collected during 2010-11 from every 1-2 kilometre distance using geographical coordinates, recorded with GPS receiver (E-TREX-VISTA, Garmin). Sampling intensity was higher in pockets having larger proportion of potato crop and sampling was done after field preparation and before application of fertilizers or organic manures. In the selected fields, soil sampling was done at several points in *zig-zag* manner, using tube augers and composite soil samples were prepared using standard technique. The soil samples so collected were dried and passed through 2 mm sieve. The soil samples were analysed for pH in 1:2 soil: water suspension, organic carbon by wet acid oxidation of organic matter (Walkley and Black, 1947), available nitrogen, phosphorus and potassium by following the methodology described by Subbiah and Asija (1956), Olsen *et al.* (1954) and Jackson (1971) method, respectively.

Geo-statistics and interpolation maps

The database soil sample points marked using GPS were fed into the GIS environment in digitized map of Hoshiarpur district. Values of different parameters (like pH, OC, available N, P and K) were tagged with corresponding points and interpolation maps for each individual parameter were prepared using suitable semivariogram and kriging in remote sensing GIS software "Geomatica". The maps generated for N, P and K were later classified, taking the ranges for different parameters suitable for potato cultivation. The integrated classified maps of N, P and K were generated to find out specific locale single deficiency. GIS software was also used to estimate the area falling under different classes of available nutrients.

RESULTS AND DISCUSSION

Soil reaction and organic carbon

The soils of the district in general were slightly acidic to slightly alkaline in reaction. The soil pH varied from 5.0 to 8.2 with a mean value of 6.8 and hence was classified in five categories. As per **Table 1**, 8.5, 24.3, 28.6, 28.6, 9.6 and 0.6 percent soils were in the pH category of < 6.0, 6.1 to 6.5, 6.6 to 7.0 , 7.1 to 7.5, 7.6 to 8.0 and more than 8.0, respectively. About 90% of the total potato area had pH less than 7.5 is considered suitable for potato cultivation.

The organic carbon in these soils ranges from low to medium (0.2 to 0.7%) with an

Table 1. Per cent soil samples falling in different ranges of pH and organic carbon.

pH	Samples (%)	Organic carbon (%)	Samples (%)
<6.0	8.5	<0.2	0.6
6.1-6.5	24.3	0.21-0.30	10.7
6.6-7.0	28.6	0.31-0.40	43.5
7.1-7.5	28.6	0.41-0.50	32.2
7.6-8.0	9.6	>0.50	13.0
>8.0	0.6	-	-

average value of 0.40%. Area under organic carbon in range <0.20, 0.21 to 0.30, 0.31 to 0.40, 0.41 to 0.50 and >0.50% was 0.6, 10.7, 43.5, 32.2 and 13.0%, respectively **(Table 1)**. Only 13% of soil samples falling in medium category in organic carbon indicates very precarious situation of soil health in these pockets. In majority of area, rice/maize-potato-wheat cropping system is being followed. The crop stubbles are never incorporated in the soil and are burned after harvest to make field quickly available for subsequent crop. These facts might have resulted in decrease of organic matter in these soils over a period of time. The continuous use of high analysis N and P fertilizers in the intensive cropping system in Punjab with the diminishing use of organic manures may also have resulted in the depletion of organic carbon (Sood, *et al.*, 2009).

Macronutrients

Available nitrogen: Available nitrogen ranged from 186.3 to 355.6 kg/ha with mean value of 242.5 kg/ha. In all, 89.6% samples were low in available N and remaining 10.4% samples tested medium in available N status **(Table 2)**. Among the macronutrients, nitrogen requirement of potato crop is the highest and it is the first limiting factor (Trehan, *et al.*, 2008). A perusal of soil N reveals that nitrogen is the most deficient nutrient in these soils and should be supplemented as per soil test. The low soil N may be due to very low efficiency of applied nitrogen fertilizer, as N is lost through various mechanisms *viz* leaching, ammonia volatilization, denitrification and runoff (De Datta and Buresh, 1989).

Phosphorus: As per **Table 2** area under medium and high available phosphorus was 11.3, and 88.7%, respectively. Keeping in view the critical limit fixed for potato in these soils, more than 88% samples are showing available P more than 20 ppm and thus suggests build-up in soils. The absence of any deficiency of available P, suggests very liberal use of P fertilizers. Potato crop takes up only 10-15% of applied P during the growing season (Trehan *et al.*, 2008) and the rest remains in soil in the form of less soluble products. The continuous application of phosphatic fertilizers to individual crop in potato based cropping systems generally results in the positive balance of this nutrient in soil. This results in very low efficiency of applied P (Sharma, 2004 and Sharma *et al.*,

Table 2. Per cent soil samples falling in different ranges of organic carbon, N, P and K.

Properties/nutrient	Soil (%)			Range of soil properties		
	Low	Medium	High	Minimum	Maximum	Average
pH	-	-	-	5.0	8.2	6.8
OC (%)	87.0	13.0	Nil	0.2	0.7	0.40
Available nitrogen (kg/ ha)	89.6	10.4	Nil	186.3	355.6	242.5
Available phosphoruas (ppm)	Nil	11.3	88.7	10.1	53.9	28.6
Available potassium (ppm)	79.1	19.2	1.7	67.5	189.0	95.9

2008). It is therefore, essential to apply soil test based phosphorus application.

Potassium: Taking into consideration the critical limits fixed for these soils (Trehan *et al.*, 2008), less than 2% samples were found to be high in available potassium, 79% low and remaining 19% samples tested medium in available potassium **(Table 2)**. Potato crop being high utilizer of potassium, its uptake often exceeds that of nitrogen. In fact, most of the potato based cropping systems have negative balance of potassium and different crops in the system do not show as much response to applied potassium as that of nitrogen leading to its lower application rate. This is taking toll on available potassium status in these soils. The continuous drain of K from the soil reserve over the years, without its replenishment has resulted in, the deficiency of K appearing in all the potato growing pockets of Hoshiarpur district (Sharma *et al.*, 2008).

Spatial distribution of available macro and micronutrients

Spatial variability maps prepared after kriging of point values of different nutrients and its classification clearly showed the specific locations of the pockets, where attention is required with respect to management of major nutrients.

Soil pH and organic carbon: After kriging for soil pH and classification in to the five classes in the range of <6.0, 6.0 to 6.5, 6.5 to 7.0, 7.0 to 7.5 and 7.5 to 8.0, area falling under these categories were 5.1, 27.9, 52.1, 14.1 and 0.8%, respectively **(Table 3)**. None of the samples had pH more than 8.0 and more than 94% of the potato growing soils were in 6.0 to 7.5 pH ranges hence suitable for potato cultivation. Similarly, area under soil organic carbon content for 0.2 - 0.3, 0.3 - 0.4, 0.4 - 0.5 and >0.5 per cent ranges was 0.3, 19.2, 55.6 and 24.9 per cent, respectively. As per the table none of soil sample had OC <0.2%.

Nitrogen: None of the potato growing area was found high in available nitrogen and 63% area (low in N content) had less than 280 kg N/ha. Remaining 37% of area (medium in N content) had more than 280 kg N/ha. The intensive and exhaustive cropping systems being followed in the region, characterized by light textured soils, low fertility status, poor water holding capacity, almost no recycling of crop residue and negligible availability of FYM, has resulted in severe reduction in soil available nitrogen.

Phosphorus: The area under medium, high and very high available phosphorus was 10.0, 39.3 and 50.6 per cent, respectively. The corresponding number of samples under

Table 3. Per cent of potato growing area falling in different ranges of pH, organic carbon, available nitrogen, phosphorus and potassium.

pH		OC		Available N		Available K		Available P	
Range	Area (%)	Range (%)	Area (%)	Range (kg/ha)	Area (%)	Range (ppm)	Area (%)	Range (ppm)	Area (%)
<6.0	5.13	<0.2	0.00	<150	0.00	<105	82.33	<20	10.0
6.0-6.5	27.9	0.2-0.3	0.3	150-280	62.7	105-150	17.1	20-30	39.3
6.5-7.0	52.1	0.3-0.4	19.2	>280	37.3	>150	0.6	>30	50.6
7.0-7.5	14.1	0.4-0.5	55.6	-	-	-	-	-	-
7.5-8.0	0.8	>0.5	24.9	-	-	-	-	-	-
>8	0.0	-	-	-	-	-	-	-	-

medium and high to very high phosphorus were 11.3% and 88.7 per cent, respectively **(Table 3 and Fig. 1)**. The results thus reveal that due to poor use efficiency of phosphorus by the potato crop and its regular application to all crops in the system it has resulted into high soil build-up in potato based cropping system. The high soil P also pose threat to nutrient balance and accelerated eutrophication of water bodies.

Potassium: About 83 and 17 per cent of area under potato growing pockets in the district was low (<105 ppm) and medium in available potassium (>105-150 ppm), respectively with 79.1 and 19.2 per cent of corresponding soil samples **(Table 3 and Fig. 1)**. The low

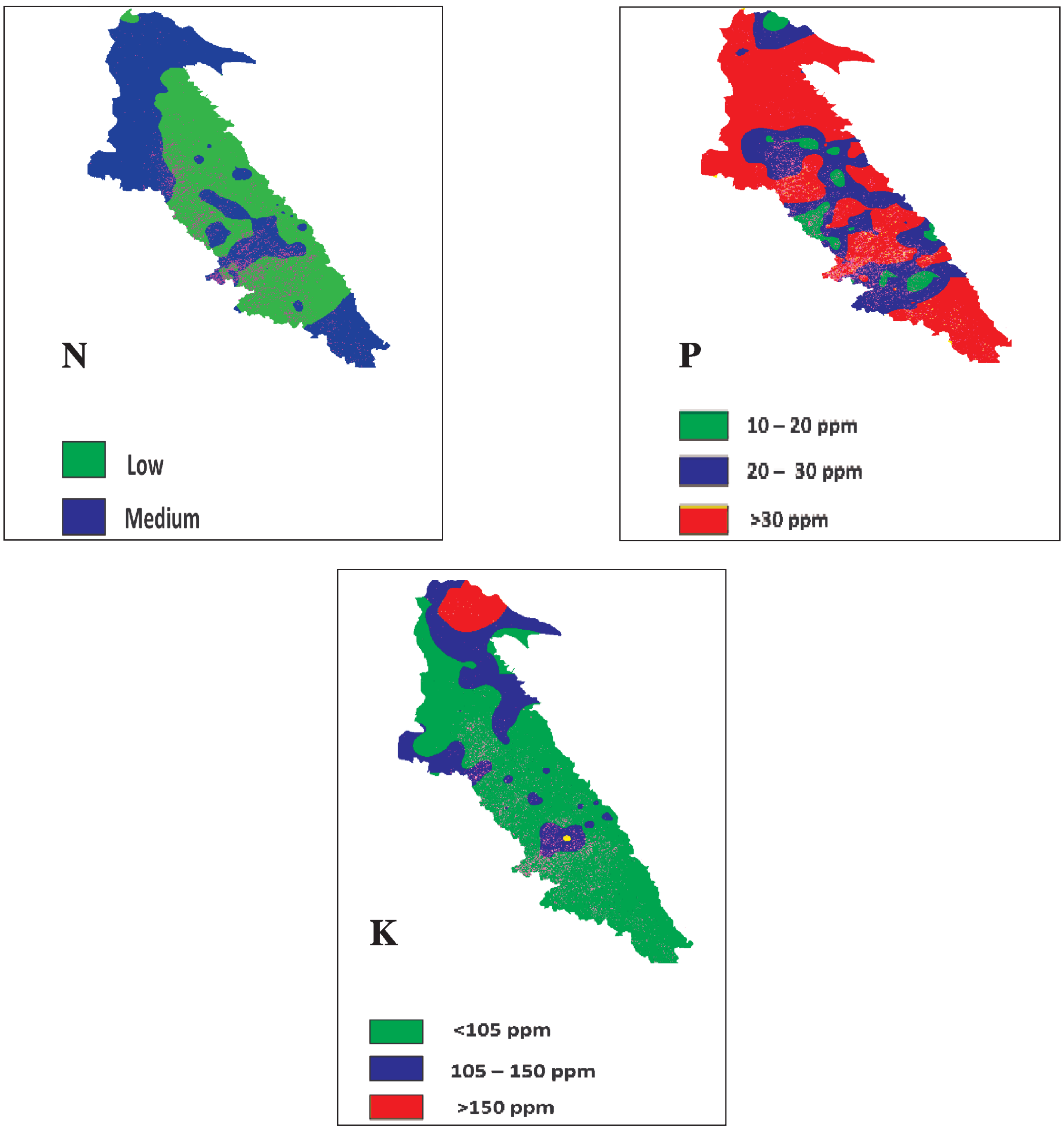

Fig. 1. Spatial distribution of available N, P and K in potato growing pockets of Hoshiarpur district of Punjab (pink pixels represent potato area).

availability status of K is the result of sandy loam soil texture, very intensive cultivation and poor cation holding capacity of soils in these pockets. Potato crop is one of the most exhaustive crop for soil potassium and potato based cropping systems often have negative balance for this nutrient. Thus in these pockets, there appears to be severe pressure on soil K reserve and to maintain that reserve there is a need to apply requisite amount of potassium to replenish its removal by the respective crops of the system.

An integration of N, P and K map by overlapping has brought out in eighteen different classes of N, P and K (**Table 4**). In all about 49.24% area was under high and very high in P, but low in N and K. Similarly, about 17.27% area was medium in available N, very high in P and low in available K, while 12.79% area was medium in both available N and K but very high in P. Thus, while recommending fertilizer for these areas, the available soil nutrient status must be considered.

Table 4. Area under various multi macronutrient deficiency categories of potato growing regions in Hoshiarpur district (Punjab).

S. N.	Available			
	N	P	K	Area (%)
1	L	M	L	9.38
2	L	M	M	0.21
3	L	M	H	0.00
4	L	H	L	30.49
5	L	H	M	0.32
6	L	H	H	0.00
7	L	VH	L	18.75
8	L	VH	M	3.50
9	L	VH	H	0.00
10	M	M	L	0.40
11	M	M	M	0.00
12	M	M	H	0.03
13	M	H	L	8.02
14	M	H	M	0.22
15	M	H	H	0.28
16	M	VH	L	15.27
17	M	VH	M	12.79
18	M	VH	H	0.31

L=low, M=medium, H=high, VH=very high

CONCLUSIONS

This study has highlighted that soils of almost whole of the area are low in OC, N and K. The N and K deficiency has appeared due to lack of balanced application of fertilizers by most of the farmers thus suggesting the need for using fertilizers on the basis of soil test values. The spatial classified maps generated under the study will be useful for identifying specific locale of potato growing pockets with different nutrient management problems. With the identification of locales with one or more macronutrients deficiency, it is possible to suggest site specific recommendations.

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