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Assessment of Soil Fertility Status in a Cereal Based Cropping System at Outer Himalayas of Himachal Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author GN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author VKS managed the analyses of the study. Authors Anjali and DS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Soil fertility management plays a key role in sustaining different production systems. Present investigation aimed at determining available nutrient status in cultivated soils under maize-wheat and paddy-wheat cropping sequences in outer Himalayas of Himachal Pradesh. Based on the standard GPS based soil sampling methodology, composite surface soil samples (0-15 cm) from 38 and 15 representative sites were collected from soils under maize-wheat and paddy-wheat cropping sequences, respectively. Six to eight cores of surface soils were collected from croplands to make one composite sample in 2016 & 2017. Out of 38 (maize-wheat) sites, 24 and 14 sites represent the cultivated *Entisols* and *Inceptisols.* Similarly, under paddy-wheat, 8 and 7 sites represent *Entisols* and *Inceptisols*. The results of the investigation revealed that soils were medium in available N & K, low in available P & S, high in available Ca & Mg, sufficient in available Cu, Fe & Mn and deficient to sufficient in available Zn and B. *Inceptisols* had higher value of all the nutrients as compared to *Entisols.* The available nutrient status *viz.,* N, P, S, Zn and B were deficient to the extent of 26, 42, 57, 40 and 42 per cent, respectively. The overall evaluation of the study area revealed very high variation on the fertility status.

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Keywords: Rice-wheat; maize-wheat; entisols; inceptisols; soil fertility; available nutrient status.

1. INTRODUCTION

The rice-wheat and maize-wheat rotation are the principal cropping system in south Asian Countries. This cropping system (R-W) is dominant in most Indian states, such as Punjab, Haryana, Bihar, Uttar Pradesh and Madhya Pradesh, and contributes to 75% of the national food grain production. This cropping system is also very prevalent in Himachal Pradesh. In Himachal Pradesh 84% of the cropped area is rainfed. Maize-wheat is the most important cropping sequence occupies an area of 111780 ha as against 21600 ha under rice-wheat cropping system [1]. The productivity of these sequences is low which needs to be increased. The continuous cropping of these cereals for several decades has shown evidence of soil nutrient depletion [2,3] due to inadequate and imbalance fertilization. The production and productivity of both the crops are very low in comparisons to the neighbouring states like Haryana and Punjab. Low productivity in the hilly state might be due to small land holdings, difficult terrain, poor soil fertility and fragile ecosystems. Agro-climatically, the State has been divided into four zones *viz.*, low hill sub-tropical zone (Outer Himalayas), mid hill sub-humid zone (Lesser Himalayas), high hill wet temperate zone (Lesser Himalayas) and high hill dry temperate zone (Greater Himalayas). Among all, the Outer Himalayas i.e., low hill sub-tropical zone has greater agricultural and horticultural significance in the State. It lies between 30°6′ N to 32°5′ N latitude and 75°5′ E to 77°5′ E longitude, with an altitude ranging from 350 to 650 m above mean sea level. It is spread over an area of 9.13 lakh hectares in Una, Bilaspur, Hamirpur, Sirmaur, Kangra and Solan districts of Himachal Pradesh. It comprises of 39.5 per cent of total cultivated area of Himachal Pradesh (9, 386 km^2). However, information on fertility status of soils under cereal cultivation in the low hill conditions of Himachal Pradesh is lacking. Therefore, an attempt was made to assess the fertility status of cereal growing *Entisols* and *Inceptisols* of Outer Himalayas of Himachal Pradesh. This information on soil fertility would help in nutrition recommendation resulting in better soil health.

2. MATERIALS AND METHODS

2.1 Site Details

The study was conducted in major physiographic region of Himachal Pradesh *viz.,* Outer Himalayan region. This region is generally characterized by the subtropical climate with the length of growing period (LGP) varying from 180 to 270 days. Mean annual temperature lies between 15°C to 23°C. The average annual rainfall is about 1100 mm. Soil moisture and temperature regimes in the region are ustic and thermic, respectively. Generally, soils are shallow to medium in depth, coarse-textured, neutral in reaction, non-calcareous to calcareous and low in soil fertility [4]. *Entisols* are predominant on hill slopes and alluvial plains, while *Inceptisols* occur mainly on gently sloping side-slopes/ ridge tops [5]. The agricultural lands in Outer/Shiwalik Himalayan region of Himachal Pradesh are under maize-wheat sequence and paddy-wheat sequence.

2.2 Soil Sampling and Analysis

Fifty-three soil sampling sites were selected to represent the cultivated soils under cereal based land-use system in the study area. Out of fifty-three sites, 32 and 21 sites represent the cultivated *Entisols* and *Inceptisols*. We used stratified random sampling methodology for collecting soil samples from the study area. These sites represent the soils under maize-wheat and paddy-wheat. Keeping in view the zone of feeding roots, composite surface soil samples (0-15 cm) were collected from selected sites. We collected 6 to 8 cores of surface soils to make one composite sample. Geo-referenced soil samples were collected from croplands during October, 2016 & 2017. The collected samples were air dried, lightly crushed in wooden pestle and mortar to break clods and then sieved through the 2 mm sieve and stored in polythene bags for analysis. The processed soil samples were analysed for available macro and micro-nutrients viz., Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn) and boron (B). Available N was determined by alkaline potassium permanganate method [6]. Available P was determined by 0.5 *M* sodium bicarbonate-extractant [7]. Available K in the soil was extracted by neutral *N* ammonium acetate and K was determined by flame photometer [8]. Available S by calcium chloride extraction method [9]. Available Ca and Mg extracted by 1 *N* ammonium acetate method, [10]. The available Fe, Mn, Zn and Cu in soil samples were estimated by atomic absorption spectrophotometer following diethylene triamine penta-acetic acid (DTPA) extraction method [11]. Available B by hot water extractable method, [12].

Soils were categorized as low, medium and high by using the same limits as adopted by the State Soil Testing Laboratories. A soil having available nutrient content ranging from 280 to 560 kg N ha^{-1}, 10 to 25 kg P ha^{-1}, 118 to 280 kg K ha^{-1}, 1.5 to 2.5 cmol(p+) Ca kg^{-1}, 0.5 to 1.0 cmol(p+) Mg kg^{-1} and 22.4 to 44.8 kg S ha^{-1} is rated as medium in the respective nutrient status. Using 0.2 mg Cu kg^{-1}, 4.5 mg Fe kg^{-1}, 1.0 mg Mn kg^{-1}, 0.6 mg Zn kg^{-1} and 0.5 mg B kg^{-1} as critical limits, soils were rated as deficient or sufficient in the respective micro nutrient. Soil nutrient indices (SNI) were also worked out to depict the overall available status of each macro-nutrient in soils by using the formula given below [13]:

$$\text{Soil Nutrient Index} = \{(N_l \times 1) + (N_m \times 2) + (N_h \times 3)\}/ N_t$$

Where,

N_l = Number of samples falling in low category of nutrient status
N_m = Number of samples falling in medium category of nutrient status
N_h = Number of samples falling in high category of nutrient status
N_t = Total number of samples analyzed for a nutrient in any given area.

Further, on the basis of SNI, soil fertility level in respect of different nutrients was categorized as low (<1.67), medium (1.67 to 2.33) and high (>2.33).

The descriptive statistics like minimum, maximum, mean and standard deviation were calculated for each property using MS Excel (MS office 2010) spreadsheet.

3. RESULTS AND DISCUSSION

3.1 Soils Under Maize-Wheat Sequence

Available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) in cultivated soils under maize-wheat sequence varied from 132 to 554, 5.2 to 15.8, 118 to 268, 2.4 to 6.5, 0.6 to 3.2 and 7 to 40 with mean values of 333, 9.9, 177, 4.1, 1.5 and 21, respectively (Table 1). On the basis of SNI, soils were rated as medium (1.68), low (1.50), medium (2.00), high (2.97), high (2.82) and low (1.39) in available N, P, K, Ca, Mg and S, respectively. Per cent of total soils rating low in available N, P & S were 32, 50 & 61, respectively.

Mean available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) were 310, 9.2, 162, 3.9, 1.3 and 19 in *Entisols* and 371, 11.2, 202, 4.4, 1.8 and 24 in *Inceptisols,* respectively (Table 1). *Inceptisols* had higher mean values of available N, P, K, Ca, Mg and S as compared to *Entisols.* The SNI values revealed that available N, P, K, Ca, Mg and S status was low (1.62), low (1.42), medium (2.00), high (2.96), high (2.75) and low (1.33) in *Entisols* and medium (1.78), low (1.64), medium (2.00), high (3.00), high (2.93) and low (1.50) in *Inceptisols,* respectively.

The distribution of available Cu, Fe, Mn, Zn and B in soils ranged from 0.16 to 0.48, 4.6 to 14.0, 1.4 to 3.8, 0.40 to 0.74 and 0.32 to 0.67 mg kg^{-1} with mean values of 0.28, 8.6, 2.4, 0.60 and 0.46 mg kg^{-1}, respectively. All soils studied were sufficient in available Cu, Fe and Mn. Per cent of total soils rating deficient in available Zn and B were 37 and 60.

Mean available Cu, Fe, Mn, Zn and Bin soils were 0.26, 7.9, 2.2, 0.58 and 0.44 mg kg^{-1} in *Entisols* and 0.32, 9.8, 2.7, 0.65 and 0.49 mg kg^{-1} in *Inceptisols*, respectively. *Inceptisols* contained higher mean available Cu, Fe, Mn, Zn and B values than those *Entisols* (Table 2).

3.2 Soils Under Paddy-Wheat Sequence

Available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) in cultivated soils under paddy-wheat sequence varied from 163 to 502, 7.2 to 14.5, 138 to 268, 3.1 to 5.0, 1.0 to 2.4 and 10 to 36 with mean values of 392, 11.6, 182, 4.0, 1.5 and 24, respectively (Table 3). On the basis of SNI values, available N, P, K, Ca, Mg and S status in soils was medium (1.87), medium (1.80), medium (2.00), high (3.00), high (2.87) and low (1.53), respectively. Per cent of total soils low in available N, P & S were 13, 20 & 47.

Mean available N (kg ha^{-1}), P (kg ha^{-1}), K (kg ha^{-1}), Ca {cmol(p+) kg^{-1}}, Mg {cmol(p+) kg^{-1}} and S (kg ha^{-1}) were 368, 11.0, 178, 3.9, 1.5 and 23 in *Entisols* and 420, 12.2, 186, 4.1, 1.6 and 26 in *Inceptisols,* respectively (Table 3). *Inceptisols* had higher mean values of available N, P, K, Ca, Mg and S as compared to *Entisols.* The SNI values revealed that available N, P, K, Ca, Mg and S status was medium (1.75), low (1.62), medium (2.00), high (3.00), high (2.88) and low (1.50) in *Entisols* and medium (2.00), medium (2.00), medium (2.00), high (3.00), high (2.86) and low (1.57) in *Inceptisols,* respectively.

Table 1. Available macronutrient status of soils under *Entisols* and *Inceptisols* of maize-wheat sequence in Outer Himalayan region of Himachal Pradesh

SN	Site	Available macronutrients					
		N	P	K	Ca	Mg	S
		(kg ha^{-1})			{cmol(p+) kg^{-1}}		(kg ha^{-1})
Entisols							
1	Raipur-I	132	6.0	138	3.2	1.1	7
2	Raipur-II	147	5.4	130	3.1	1.1	10
3	Dilwan	147	6.0	124	2.8	1.0	12
4	Dadhuwala-I	325	9.0	208	4.8	1.9	20
5	Akrot	218	7.4	138	3.2	1.1	13
6	Gangath-I	310	9.4	120	4.9	1.0	18
7	Sugal	432	12.6	168	4.0	1.4	26
8	Balardu	378	11.2	180	3.9	1.5	23
9	Harsar	478	13.2	204	4.5	1.6	32
10	Jachh-I	336	9.6	124	2.4	0.6	21
11	Bassa Waziran-I	310	8.4	150	3.9	1.6	20
12	Bhedli	245	7.4	118	3.0	0.9	15
13	Bhanjal	245	7.0	142	3.4	1.3	14
14	Tika Patiala	316	7.8	214	5.9	2.5	19
15	Bandh	410	12.0	244	4.6	1.8	23
16	Balahar	245	6.8	126	2.9	1.1	13
17	Panjahra-I	410	11.2	138	4.7	1.2	25
18	Kanghain	257	7.6	154	2.9	1.3	18
19	Dabi	325	10.6	164	3.6	1.6	20
20	Deru Bhad	290	10.2	158	4.1	0.8	26
21	Palother	492	14.8	154	3.8	1.4	30
22	Trikun	457	11.4	208	3.2	0.9	23
23	Sidh Chalehr	163	6.6	132	3.4	1.2	10
24	Ghroon	378	10.2	258	6.2	1.8	22
	Mean ± SD	**310±106.12**	**9.2±2.53**	**162±40.23**	**3.9±0.97**	**1.3±0.42**	**19±6.45**
Inceptisols							
25	Beli Diawar	502	15.2	262	4.8	2.1	37
26	Boungta	457	12.8	208	4.4	1.6	28
27	Haripur	378	11.0	204	3.9	1.6	22
28	Panjoa	132	5.2	146	3.3	1.0	7
29	Larana	410	11.8	172	4.0	1.3	25
30	Kehrian	386	12.2	172	3.8	1.5	23
31	Lal Pukhar	368	10.8	244	4.7	2.0	22
32	Maharpur	316	10.4	168	3.9	1.1	20
33	Chambed	225	9.4	224	5.9	2.5	21
34	Alampur	410	9.9	174	5.1	1.8	28
35	Sakoh	298	8.8	166	3.4	2.0	20
36	Dharoti	492	14.0	244	4.5	1.8	30
37	Har	263	8.8	180	3.9	1.5	16
38	Mauhin	554	15.8	268	6.5	3.2	40
	Mean ± SD	**371±115.85**	**11.2±2.80**	**202±39.87**	**4.4±0.91**	**1.8±0.57**	**24±8.30**
Overall Mean ± SD		**333±112.21**	**9.9±2.76**	**177±44.13**	**4.1±0.98**	**1.5±0.53**	**21±7.50**

Table 2. Available micronutrient status of soils under under *Entisols* and *Inceptisols* of maize-wheat sequence in Outer Himalayan region of Himachal Pradesh

SN	Site	Available micronutrients				
		Cu	Fe	Mn	Zn	B
		(mg kg^{-1})				
Entisols						
1	Raipur-I	0.16	7.0	2.0	0.50	0.36
2	Raipur-II	0.16	5.8	1.8	0.42	0.35
3	Dilwan	0.16	4.8	1.6	0.48	0.32
4	Dadhuwala-I	0.28	12.4	3.5	0.65	0.51
5	Akrot	0.24	6.0	2.0	0.44	0.35
6	Gangath-I	0.24	4.6	1.4	0.60	0.34
7	Sugal	0.35	8.0	2.8	0.67	0.52
8	Balardu	0.30	7.8	2.0	0.60	0.51
9	Harsar	0.39	9.8	2.8	0.61	0.55
10	Jachh-I	0.19	5.8	1.5	0.62	0.39
11	Bassa Waziran-I	0.20	8.4	2.5	0.52	0.44
12	Bhedli	0.22	6.9	1.9	0.50	0.37
13	Bhanjal	0.22	7.6	1.9	0.64	0.38
14	Tika Patiala	0.34	11.8	3.3	0.54	0.61
15	Bandh	0.32	11.4	2.8	0.72	0.51
16	Balahar	0.18	6.8	1.5	0.44	0.36
17	Panjahra-I	0.23	8.0	1.8	0.64	0.54
18	Kanghain	0.20	8.4	2.2	0.52	0.42
19	Dabi	0.26	9.2	2.2	0.68	0.46
20	Deru Bhad	0.34	8.4	2.4	0.62	0.52
21	Palother	0.40	5.6	1.8	0.64	0.47
22	Trikun	0.38	6.2	1.4	0.72	0.42
23	Sidh Chalehr	0.18	7.2	2.2	0.40	0.37
24	Ghroon	0.28	12.4	3.0	0.68	0.59
	Mean ± SD	**0.26±0.08**	**7.9±2.27**	**2.2±0.59**	**0.58±0.10**	**0.44±0.09**
Inceptisols						
25	Beli Diawar	0.42	10.4	3.7	0.70	0.58
26	Boungta	0.32	10.8	3.0	0.74	0.52
27	Haripur	0.28	8.6	2.4	0.72	0.45
28	Panjoa	0.16	7.2	1.9	0.52	0.43
29	Larana	0.30	8.6	2.4	0.70	0.44
30	Kehrian	0.35	6.0	1.9	0.54	0.42
31	Lal Pukhar	0.28	12.4	3.0	0.70	0.45
32	Maharpur	0.24	9.9	2.6	0.66	0.39
33	Chambed	0.29	12.6	2.9	0.62	0.62
34	Alampur	0.38	9.6	2.6	0.64	0.51
35	Sakoh	0.36	8.8	2.6	0.52	0.44
36	Dharoti	0.42	9.4	2.8	0.72	0.53
37	Har	0.22	8.9	2.4	0.58	0.38
38	Mauhin	0.48	14.0	3.8	0.74	0.67
	Mean ± SD	**0.32±0.09**	**9.8±2.14**	**2.7±0.56**	**0.65±0.08**	**0.49±0.09**
Overall Mean ± SD		**0.28±0.09**	**8.6±2.38**	**2.4±0.63**	**0.60±0.10**	**0.46±0.09**

As regard the distribution of micronutrients, available Cu, Fe, Mn, Zn and B in soils ranged from 0.16 to 0.42, 5.2 to 10.4, 1.7 to 3.0, 0.32 to 0.72 and 0.40 to 0.59 mg kg^{-1} with mean values of 0.32, 7.9, 2.3, 0.56 and 0.48 mg kg^{-1}, respectively (Table 3). All soils studied were sufficient in available Cu, Fe and Mn. Per cent of total soils rating deficient in available Zn and B were 47 and 60, respectively.

Table 3. Available nutrient status of soils under under *Entisols* and *Inceptisols* of paddy-wheat sequence in Outer Himalayan region of Himachal Pradesh

SN	Site	Available macronutrients						Available micronutrients				
		N	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn	B
			(kg ha^{-1})		{cmol(p+) kg^{-1}}		(kg ha^{-1})		(mg kg^{-1})			
Entisols												
1	Udheypur	163	7.2	138	3.1	1.0	10	0.16	5.8	1.7	0.44	0.50
2	Jankaur-I	257	8.0	168	3.6	1.5	16	0.26	8.2	2.6	0.42	0.46
3	Naggal	502	14.5	230	4.8	2.0	36	0.42	10.0	3.0	0.70	0.56
4	Matke Majri	325	9.8	138	3.4	1.1	19	0.26	5.2	1.7	0.32	0.40
5	Pipal Wala	447	12.6	208	4.4	1.8	26	0.34	8.5	2.5	0.52	0.47
6	Bhol	394	11.0	180	3.9	1.4	21	0.28	9.0	2.6	0.68	0.45
7	Guler	462	13.8	168	3.8	1.3	30	0.40	6.8	2.0	0.62	0.45
8	Kachhial	394	11.4	194	3.9	1.5	24	0.31	10.4	2.8	0.72	0.52
	Mean ± SD	**368±113.75**	**11.0±2.61**	**178±32.21**	**3.9±0.54**	**1.5±0.33**	**23±8.15**	**0.30±0.08**	**8.0±1.90**	**2.4±0.50**	**0.55±0.15**	**0.48±0.05**
Inceptisols												
9	Talao	492	14.2	268	5.0	2.4	33	0.40	10.4	3.0	0.64	0.59
10	Surajpur	410	12.4	154	3.9	1.4	25	0.34	6.6	1.8	0.40	0.44
11	Dadhuwala-II	352	10.4	204	4.4	1.8	22	0.28	10.0	2.8	0.54	0.45
12	Doiyanwala	386	11.4	172	4.0	1.4	22	0.34	8.8	2.6	0.66	0.52
13	Rampur Bharapur	352	10.2	146	3.6	1.0	21	0.30	6.0	1.7	0.42	0.42
14	Nahan Nagrota	457	13.2	180	3.8	1.4	28	0.39	6.8	2.0	0.66	0.51
15	Phera	492	13.8	180	4.0	1.5	32	0.38	6.6	1.9	0.60	0.47
	Mean ± SD	**420±60.88**	**12.2±1.61**	**186±40.70**	**4.1±0.47**	**1.6±0.44**	**26±4.95**	**0.35±0.05**	**7.9±1.81**	**2.3±0.53**	**0.56±0.11**	**0.49±0.06**
Overall Mean ± SD		**392±93.72**	**11.6±2.21**	**182±35.31**	**4.0±0.50**	**1.5±0.38**	**24±6.84**	**0.32±0.07**	**7.9±1.79**	**2.3±0.50**	**0.56±0.13**	**0.48±0.05**

Mean available Cu, Fe, Mn, Zn and B in soils were 0.30, 8.0, 2.4, 0.55 and 0.48 mg kg^{-1} in *Entisols* and 0.35, 7.9, 2.3, 0.56 and 0.49 mg kg^{-1} in *Inceptisols*, respectively. *Inceptisols* contained higher mean available Cu and Zn values while lower Fe and Mn values than those *Entisols* (Table 3).

The overall evaluation of the study area revealed that soils varied considerably in available nutrient content. It may be attributed to the heterogeneity in soil management practices, land use types, plant nutrient recycling processes etc Moreover, majority of the farmers applied fertilizers at rates much lower than the recommended ones in the study area. Study revealed that the levels of nutrients applied are quite inadequate as is evident that in Himachal Pradesh, N, P_2O_5, K_2O use was 32.6, 9.2, 7.6 kg/ha, respectively [14]. Moreover, the reasons might be small land holdings, difficult terrain, poor soil fertility and fragile ecosystems in Outer Himalayas.

The deficiency of five nutrients, *viz.,* N, P, S, Zn and B may impose threat to sustain the soil productivity in Outer Himalayan region. Per cent of total soil samples found deficient in N, P, S, Zn and B were 26, 42, 57, 40 and 42 per cent, respectively in Outer Himalayan region (Fig. 1). The deficiency percentage of five nutrients under Entisols and Inceptisols is presented through radar plot (Fig. 2). This showed that deficiency percentage was more in Entisols as compared to Inceptisols.

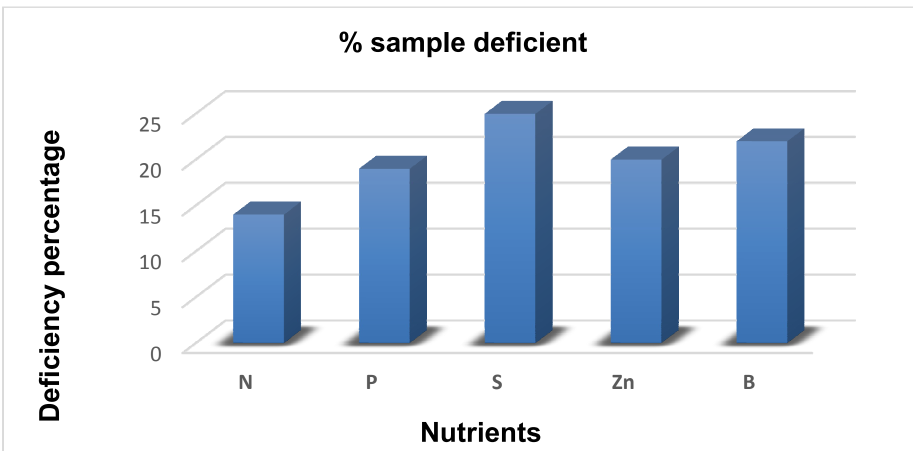

Fig. 1. Nutrient deficiency status in cereal based cultivated soils of Outer Himalayas

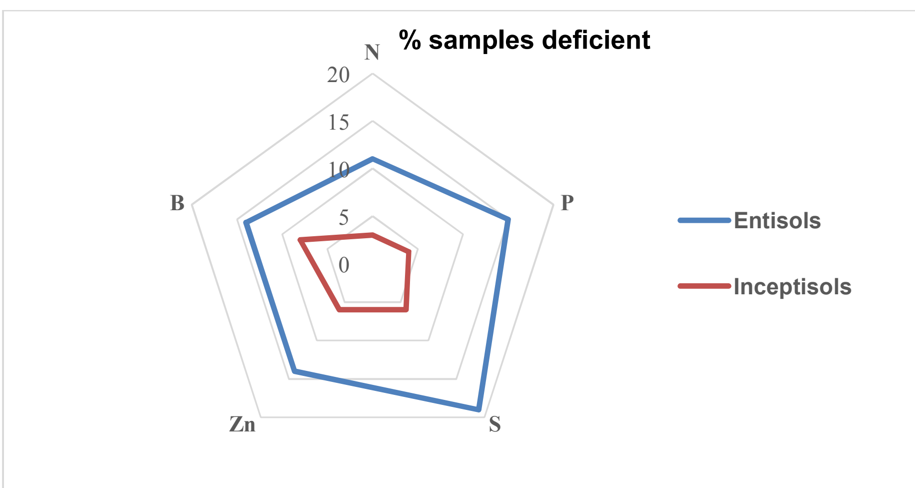

Fig. 2. Deficiency percentage of different nutrients in Entisols and Inceptisols of Outer Himalayas

4. CONCLUSIONS

It is concluded from the present investigation that the soils were medium in available N & K, low in available P & S, high in available Ca & Mg, sufficient in available Cu, Fe & Mn and deficient to sufficient in available Zn and B. *Inceptisols* had higher value of all the nutrients as compared to *Entisols.* The deficiency of five nutrients *viz.,* N, P, S, Zn and B may impose threat to sustain the soil productivity in Outer Himalayas. This study would help the farmers to increase the productivity of their lands and to improve their livelihood by formulating sound fertilizer recommendations. Thus, there is need to optimize nutrient management practices to improve soil fertility status by judicious use of balanced fertilizers blended with organic source.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sharma SK, Rana SS, Subehia SK. Response of maize - wheat cropping system to NPK in low hills of Himachal Pradesh. Himachal Journal of Agricultural Research. 2015;41(1):73-76.
2. Verma G, Sharma RP, Sharma SP, Subehia SK, Shambhavi S. Changes in soil fertility status of maize-wheat system due to long-term use of chemical fertilizers and amendments in an Alfisol. Plant Soil and Environment. 2012;58(12):529-533. DOI:10.17221/PSE
3. Meena HM, Sharma RP. Long-term effect of fertilizers and amendments on different fractions of organic matter in an acid Alfisol. Communication in Soil Science and Plant Analysis. 2016;47:1430-1440. DOI: 10.1080/00103624.2016.1178766.
4. Gupta SK, Chera RS. Soil characteristics as influenced by slope aspects in middle Siwaliks. Agropedology. 1996;6:43-48
5. Sidhu GS, Rana KPC, Sehgal J, Velayutham M. Soils of Himachal Pradesh for optimizing land-use. National Bureau of Soil Survey and Land-use Planning, Nagpur, India. 1997;44.
6. Subbiah BV, Asija GL. Rapid procedure for the estimation of available nitrogen in soil. Current Science. 1956;25:259-260.
7. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture, Washington DC, circular No. 1954;939:19.
8. Schollenberger CJ, Simon RH. Determination of exchange capacity and exchangeable bases in soil by ammonium acetate method. Soil Science. 1945;59:13-24.
9. Williams CH, Steinbergs A. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. Australian Journal of Agricultural Research. 1959;10:340-352.
10. Jackson ML. Soil Chemical Analysis. Prentice Hall, India Private Limited, New Delhi. 1973;678.
11. Lindsay WL, Norwell WA. Development of DTPA soil test for Zinc, Iron, Manganese, and Copper. Soil Science Society of America Journal. 1978;42:421-428.
12. Wolf B. The determination of boron in soil extracts, plant materials, composts, manures, water, and nutrient solutions. Communications in Soil Science and Plant Analalysis. 1971;2:363-374.
13. Parker FW, Nelson WL, Winters E, Miles IE. The broad interpretation and application of soil test information. Agronomy Journal. 1951;43:105-112.
14. Anonymous. Fertilizer News. 2004;49(9): 122.

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