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Evaluation of soil fertility status of available N, P and K in *Inceptisol* of Raipur district of Chhattisgarh

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Abstract

Grid based (GPS) surface (0-15 cm) soil samples by systematic survey were collected from 33 villages and 198 samples (each village six samples) were identified. These soil samples were analyzed for N, P and K and categorized as low medium and high as per criteria followed in the soil testing laboratory. The available nitrogen status in the surface soils ranged from 113 to 386 kg ha^{-1} with mean value of 245 kg ha^{-1} and 72% low and 28% medium. The available Olsen – P ranged from 5.05 – 30.50 kg ha^{-1} with mean value of 11.27. The percent sample category under low, medium and high was 70, 29 and 1 respectively. The overall range values recorded for available potassium status (Table 6) in surface soils of different tahsil/blocks ranged from 200 to 614 kg ha^{-1}. The percent sample category under low, medium and high 0, 17 and 83 respectively.

Key words: fertility status, major nutrients, *Inceptisol*

Introduction

In view of the finite nature of natural resources, their management in a sustained fashion has become an issue of primary concern. Sustainability of the agricultural production systems is the most crucial issue in this part of the green revolution. A system is sustainable when it improves or at least maintains the quality of soil, water and atmosphere. Application of chemical fertilizers has been rated as one of the most important production factor affecting the sustainability. The increasing population has forced farmers to make use of high doses of chemical fertilizers. Its unscientific use (nutrient imbalances, incorrect amounts) is a serious threat to sustainable agricultural production system.

Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological processes (Goovaerts, 1998). However, major constraints impede wide scale adoption of soil testing in most developing countries. In India, these include the prevalence of small holding systems of farming as well as lack of infrastructural facilities for extensive soil testing (Sen *et al.,* 2008). Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields. Soil testing program is beneficial to formulated specific fertilizer recommendations.

Study Area

Raipur district is a capital in the state of Chhattisgarh, India. The location of study area is shown in the map of Chhattisgarh state. The Raipur district consists of four tahsil/blocks *viz.,* Dharsinwa, Abhanpur, Arang and Tilda. A total of 33 villages were selected based on stratified multistage random sampling method covering all the four talukas comprising four blocks and a total of 198 surface soil samples (six from each village) were collected using GPS representing small (< 1 ha.), medium (1 to 3

ha.) and large (>3 ha.) farmers' category . The major four soil orders (*Inceptisols*, *Vertisoils*, *Entisoils* and *Alfisoils*) of the covered under the different villages of the Raipur district of Chhattisgarh has been taken for fertility evaluation on various aspects.

Material and Methods

Collection of soil samples

Surface (0-15 cm depth) soil samples were collected from different villages. Soil samples were collected with the help of soil auger and local spade with proper labels.

Analysis of Samples

Soil samples collected from the study area were dried and crushed with the help of wooden rod and passed through 2 mm sieve and then used for the determination of soil pH, Electrical conductivity, organic matter and macronutrients content by adopting standard laboratory methods.

Soil pH was determined by glass electrode pH (Piper, 1967), Electrical Conductivity with Solu-bridge method (Black, 1965), Organic C by wet digestion method (Walkley and Black's rapid titration method, 1934), Available nitrogen was estimated by alkaline $KMnO_4$ method (Subbiah and Asija, 1956), Available phosphorus was extracted by 0.5M $NaHCO_3$ solution buffer at pH 8.5 (Olsen *et al.*,1954) and phosphorus in the extract was determined by ascorbic acid method (Watanabe and Olsen, 1965), Available potassium was extracted by shaking with neutral normal ammonium acetate for 5 minutes (Hanway and Heidal, 1952) and then K in the extract was estimated by flame photometer. The samples were categorized as per the rating limit given in Table 1.

Table 1: Limits for the soil test values used for rating the soil

Classification for pH values			
Strongly acid	**Moderately acid**	**Slightly acid**	**Neutral**
<5.5	5.5-6.0	6.0-6.5	6.5-7.5
Classification for total soluble salt content (EC as dS m^{-1})			
No deleterious effect on crop	**Critical for germination**	**Critical for salt sensitive crop**	**Injurious to most crops**
<1.0	1.0-2.0	2.0-3.0	>3.0
Parameters	**Low**	**Medium**	**High**
O.C. (%)	0.25-0.50	0.50-0.75	>0.75
	Macronutrients		
Av. N (kg ha^{-1})	<280	280-560	>560
Av. P (kg ha^{-1})	<12.5	12.5-25	>25
Av. K (kg ha^{-1})	<135	135-335	>335

Results and Discussion

Soil reaction (pH):

The samples of the study area were determined for pH (Table 2) and observed in the range of 5.7- 8.2 with the mean value of 7.25.

pH estimation from total 198 soil samples of Raipur district and it was observed that nearly 38.98 % samples under moderately acidic (5.5-6.0), 37.59 % under slightly acidic (6.0-6.5), 15.25 % under strongly acidic (<5.5) and only 8.18 % samples were categorized under neutral soil (Table 3). The relative low pH of the soils is due to low base saturation and light textured soil.

Table 2: Range and mean values of pH in different Blocks of Raipur district

S.No	Tahsil/ Blocks	Range	Mean	% Samples category		
				Acidic	Neutral	Saline
1	Dharsinwa	6.7-7.9	7.49	-	58.49	41.51
2	Arang	5.7-8.2	7.22	14.28	47.62	38.10
3	Abhanpur	5.7-8.2	7.14	18.75	45.83	35.42
4	Tilda	6.3-7.9	7.13	12.73	61.82	25.45
Over all mean		**5.7-8.2**	**7.25**	**11.11**	**54.04**	**32.83**

Table 3: Salient soil properties of study area

Soil characteristics	Range	Mean
pH (1:2.5, Soil water)	5.7 – 8.2	7.25
E.C. (dS m^{-1})	0.02 - 0.44	0.12
O.C. (%)	0.23-0.96	0.64
Available N (kg ha^{-1})	113-386	245
Available P (kg ha^{-1})	5.05-30.50	11.27
Available K (kg ha^{-1})	200-614	481

Salt concentration (EC)

The total soluble salt content expressed as electrical conductivity (EC), varied from 0.02 to 0.44 dS m^{-1} with a mean value of 0.12 dS m^{-1} at 25^{o}C (Table 4). The results have shown the EC values under normal range (<1.0 dS m^{-1}). The normal EC may be ascribed to leaching of salts to lower horizons due to its light textured nature.

Table 4: Range and mean values of EC (dS m^{-1}) in different Blocks of Raipur district

S.No	Tahsil/ Blocks	Range	Mean	% Samples category		
				Non-saline	Slightly saline	Saline
1	Dharsinwa	0.03-0.23	0.114	100	-	-
2	Arang	0.03-0.39	0.124	100	-	-
3	Abhanpur	0.02-0.37	0.102	100	-	-
4	Tilda	0.04-0.44	0.120	100	-	-
Over all mean		**0.02-0.44**	**0.115**	**100**	**-**	**-**

Organic Carbon

The organic carbon analyzed in all sampled *Inceptisol* exhibited in the range of 0.23 to 0.96 with a mean value of 0.64 % (Table 5). Thus, the *Inceptisol* of Arang and Abhanpur block is low in Organic C content. Distribution of soil samples with respect to organic C content indicates (Table 5) that about 25 % samples had low (<0.50 %) organic C, 44 % in medium (0.50-0.75%) and only

30 % samples had higher organic C (>0.75%). Use of almost nil to very low amount of organic wastes like farm yard manure and chemical fertilizers in imbalanced manner are the main reason for poor organic C resulted low productivity of the region. More over high temperature during summer (March to June) prevailing in the area may also be responsible for the rapid burning of organic matter, thus resulting in low organic C content of these soils. Since organic matter content is an indicator of available N status of soils, thus the soils of the area are also dominantly low in respect of their available N.

Table 5: Range and mean values of organic carbon (%) in different Blocks of Raipur district

S.No	Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
				Low	Medium	High		
1	Dharsinwa	0.24-0.96	0.61	26	53	21	1.94	Medium
2	Arang	0.25-0.88	0.59	36	40	24	1.88	Medium
3	Abhanpur	0.23-0.96	0.59	35	42	23	1.88	Medium
4	Tilda	0.29-0.96	0.76	7	42	51	2.44	High
Over all mean		**0.23-0.96**	**0.64**	**25**	**44**	**30**	**2.05**	**Medium**

Available N

The available N content (Table 6) of *Inceptisol* ranged from 113 to 386 kg ha^{-1} with an average value of 245 kg ha^{-1}. The majority of the sampled area (71 %) covering in *Inceptisol* of Baloda block fall under low status (<280 kg ha^{-1}) in available N content (Table 6). Only 24 % soil samples were categorized under medium (280-560 kg ha^{-1}) status. In this way, almost all the soil samples tested were found to be deficient in N. It is fact that the available N analyzed by alkaline $KMnO_4$ method as suggested by Subbiah and Asija (1956) do not exhibit the exact availability of N in dry soil. It is the measure of the oxidisable N in dry soil. It is quite obvious that being a mobile nature and low uptake recovery due to its losses through various mechanism like NH_3 volatilization, nitrification, succeeding, denitrification, chemical and microbial fixation, leaching and runoff (De Datta and Buresh, 1989) residual/available N becomes poor in soil.

Table 6: Range and mean values of avilable N (kg/ha) in different Blocks of Raipur district

S.No	Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
				Low	Medium	High		
1	Dharsinwa	111-378	237	79	21	0	1.21	Low
2	Arang	118-308	229	76	24	0	1.24	Low
3	Abhanpur	114-335	230	81	19	0	1.19	Low
4	Tilda	140-386	277	51	49	0	1.49	Low
Over all mean		**113-386**	**245**	**71**	**29**	**0**	**1.30**	**Low**

Available P

The available P varied from 5.05 to 30.50 kg ha^{-1} with a mean value 11.27 kg ha^{-1} in *Inceptisol* (Table 7). The study indicates that about 70 % of the sampled area exhibited low and 29 % under medium and 1 % in high range of P content. Phosphorus is present in soil as solid phase with varying degree of solubility. When water soluble P is added to the soil, it is converted very

quickly to insoluble solid phase by reacting with soil constituents. These may include calcium Cate (Olsen, 1953), Fe and Al oxides (Dean and Rubins, 1947 and Chu *et.al.*, 1962) and partly organic matter. The added P is more likely to be absorbed on hydrated Fe and Al oxides or on the edge of the clay minerals in neutral to acidic range of soils (Russell, 1988). These reactions affect the availability of P and as a result of these reactions, a very small amount of total P is present in soil solution at any time reflected by soil testing. However, a low to medium range of soils available P under study area may be mostly affected by past fertilization, pH, organic matter content, texture and various soil management and agronomic practices (Verma *et al.*, 2005).

Table 7: Range and mean values of avilable P (kg/ha) in different Blocks of Raipur district

S.No	Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
				Low	Medium	High		
1	Dharsinwa	5.59-30.50	11.29	79	19	2	1.23	Low
2	Arang	5.16-19.17	12.02	48	52	0	1.52	Low
3	Abhanpur	5.16-18.55	10.95	75	25	0	1.25	Low
4	Tilda	5.05-23.83	10.97	75	25	0	1.25	Low
Over all mean		**5.05-30.50**	**11.27**	**70**	**29**	**1**	**1.30**	**Low**

Available K

The available K content (Table 8) in *Inceptisol* ranged from 200 to 614 kg ha^{-1} with an overall average value 418 kg ha^{-1}. The data reveals that 83 % soil samples tested were in high level of available K and only 17 % samples were tested under medium range (Table 8). Adequate level of available K in *Inceptisol* of the study area may be attributed to the prevalence of K-rich clay minerals like *illite* and *kaolinite.*

Table 8: Range and mean values of avilable K (kg/ha) in different Blocks of Raipur district

S.No	Tahsil/ Blocks	Range	Mean	% Samples category			Nutrient Index	Fertility Rating
				Low	Medium	High		
1	Dharsinwa	348-614	558	0	0	100	3.00	High
2	Arang	207-606	448	0	14	86	2.86	High
3	Abhanpur	200-602	421	0	31	69	2.69	High
4	Tilda	293-605	448	0	22	78	2.78	High
Over all mean		**200-614**	**481**	**0**	**17**	**83**	**2.83**	**High**

Conclusion:

It can be concluded from the results under study that the *Inceptisol* group of Raipur district of Chhattisgarh is characterized under moderate to neutral in soil reaction, soluble salt content comes under safe limit for all crops. The organic carbon level exhibited low to medium. The *Inceptisol* of the area showed low in available N and P, and medium level in available K. Hence, the soils require attention regarding nutrient management practices and regular monitoring of soil health for better crop production.

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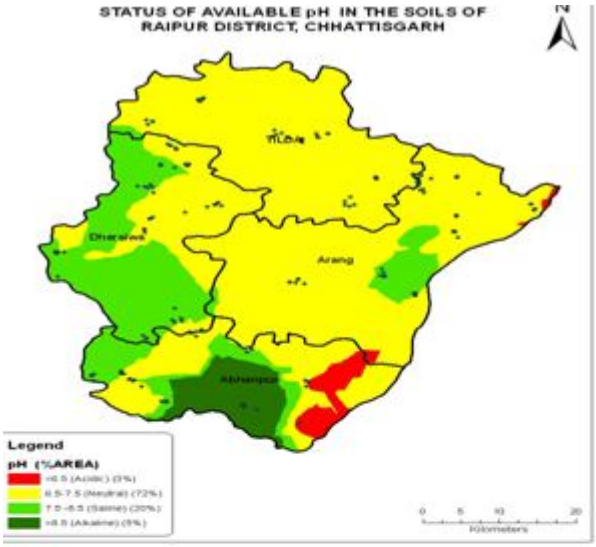
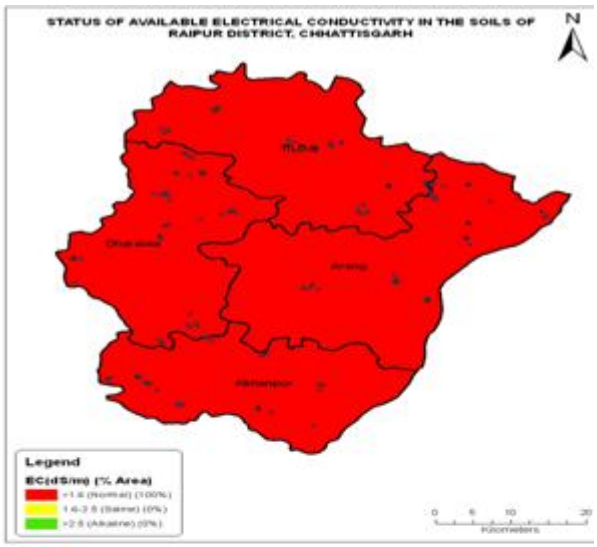
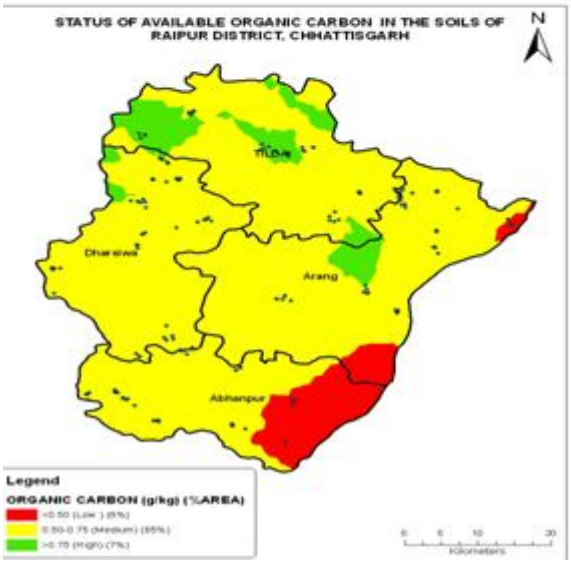
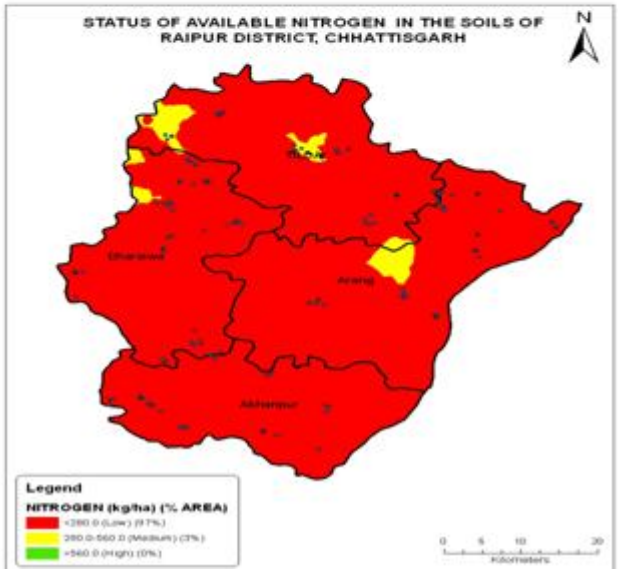
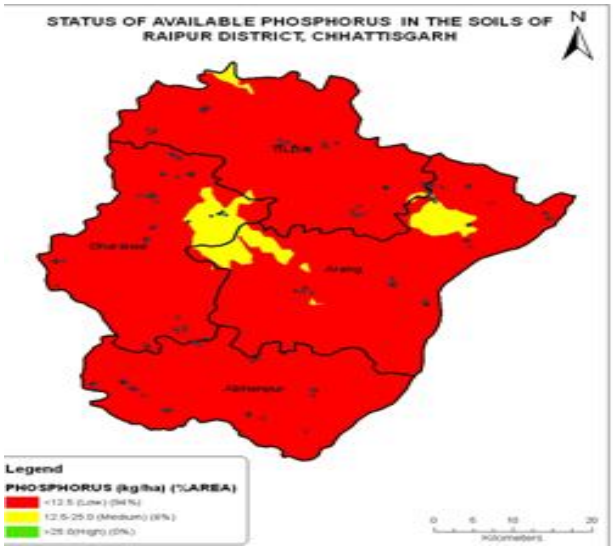
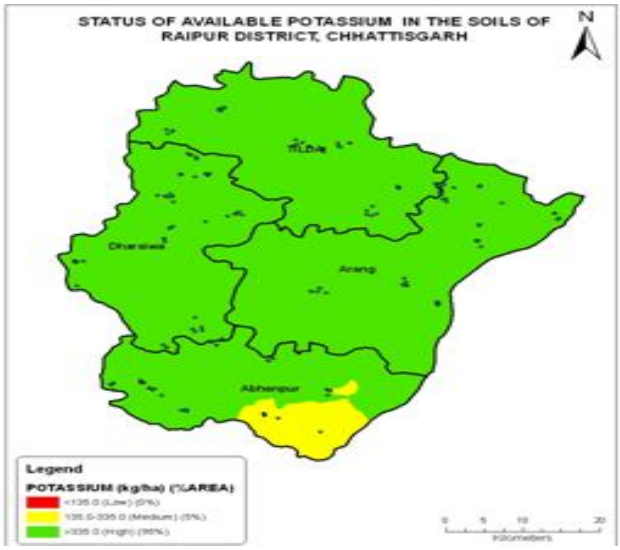

STATUS OF AVAILABLE pH IN THE SOILS OF
RAIPUR DISTRICT, CHHATTISGARH
N
Dharsiwa
Arang
Abhanpur
Legend
pH (%AREA)
<6.5 (Acidic) (3%)
6.5-7.5 (Neutral) (72%)
7.5 -8.5 (Saline) (20%)
>8.5 (Alkaline) (5%)
0 5 10 20
Kilometers


STATUS OF AVAILABLE ELECTRICAL CONDUCTIVITY IN THE SOILS OF
RAIPUR DISTRICT, CHHATTISGARH
N
Dharsiwa
Arang
Abhanpur
Legend
EC(dS/m) (% Area)
<1.6 (Normal) (100%)
1.6-2.5 (Saline) (0%)
>2.5 (Alkaline) (0%)
0 5 10 20
Kilometers


STATUS OF AVAILABLE ORGANIC CARBON IN THE SOILS OF
RAIPUR DISTRICT, CHHATTISGARH
N
Dharsiwa
Arang
Abhanpur
Legend
ORGANIC CARBON (g/kg) (%AREA)
<0.50 (Low) (8%)
0.50-0.75 (Medium) (85%)
>0.75 (High) (7%)
0 5 10 20
Kilometers


STATUS OF AVAILABLE NITROGEN IN THE SOILS OF
RAIPUR DISTRICT, CHHATTISGARH
N
Dharsiwa
Arang
Abhanpur
Legend
NITROGEN (kg/ha) (% AREA)
<280.0 (Low) (97%)
280.0-560.0 (Medium) (3%)
>560.0 (High) (0%)
0 5 10 20
Kilometers


STATUS OF AVAILABLE PHOSPHORUS IN THE SOILS OF
RAIPUR DISTRICT, CHHATTISGARH
N
Dharsiwa
Arang
Abhanpur
Legend
PHOSPHORUS (kg/ha) (%AREA)
<12.5 (Low) (94%)
12.5-25.0 (Medium) (6%)
>25.0 (High) (0%)
0 5 10 20
Kilometers


STATUS OF AVAILABLE POTASSIUM IN THE SOILS OF
RAIPUR DISTRICT, CHHATTISGARH
N
Dharsiwa
Arang
Abhanpur
Legend
POTASSIUM (kg/ha) (%AREA)
<135.0 (Low) (0%)
135.0-335.0 (Medium) (5%)
>335.0 (High) (95%)
0 5 10 20
Kilometers