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SOIL FERTILITY EVALUATION OF NIGNOTI VILLAGE OF INDORE DISTRICT

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ABSTRACT

Study revealed that, pH of *Vertisols* of Nignoti village varied from 7.0 to 8 .0. EC ranged from 0.11 to 1.09 dsm-1.SOC varied from 0.23% to 0.80%. In general, the SOC status was low to medium. Available N ranged from 114 to 300 kg ha-1 with an average of 213.4 kg ha-1. Available-P varied from 6 to 30.4 kg ha-1 with a mean value of 17.3 kg ha-1. 22.47% soil samples are classified as low fertility class and 64.8 % in medium fertility class. 97.6% soil samples were found high in available-K. Available-S varied from 5.02 to 35.66 kg ha-1. 76.36% samples were classified as low fertility class, 23.63% as medium fertility class. Available zinc varied from 0.2 to 1.94 mg kg-1 with a mean value of 0.64 mgkg-1.Out of 361.23 ha area 97.34 ha has the status of multi-nutrients as low in N, S, Zn, medium in P, Cu, Fe, Mn and high in K. 91.87 ha area was under low N and S, medium in P,Zn,Cu,Fe, Mn and high in K status.The spatial distribution map will help in site specific nutrient management in the village for sustinable crop production an soil health management.

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INTRODUCTION

Intensively cultivated soils are being depleted with available nutrients especially secondary and micronutrients. Therefore, assessment of fertility status of soils that are being intensively cultivated with high yielding crops needs to be carried out. Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site specific recommendations and subsequent monitoring. Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally.Under this context, GIS-based soil fertility mapping has appeared as a promising alternative (Burgess and Webster, 1980, Chevallier *et al.,* 2000 and Zhang and Srinivasan, 2009 and Mali and Singh, 2015). Use of such maps as a decision support tool for nutrient management,will not only be helpful for adopting a rational approach compared to farmer practices or blanket use of state recommended fertilization, but will also reduce the necessity for elaborate plot-by-plot soil testing activities. However, information pertaining to such use of GIS-based fertility maps has been meager in India. The current study was carried out to assess the GIS map-based soil fertility evaluation with regard to traditional soil testing in the Nignoti village of western MP. This study presents the soil spatial variability maps for soil, pH, electrical conductivity, organic carbon, available –N, P, K, S, Zn, along with multi nutrient deficiency maps. The information generated will be useful for managing soil resources of the village on sustainable basis.The approaches like Integrated Nutrient management, balance fertilization, site specific nutrient management will be possible if this kind of fertility maps are available for a village (Chandravanshi *et al.,* 2014). If we adopt proper nutrient management studies one can improve soil and crop quality also (Choudhery and Bhatia, 2008, Watham *et al.*, 2014 Prasad *et al.*, 2014, Vanilarasu *et al.*, 2014).

The basic objectives of the study was to evaluate soil fertility status of the village and prepare soil fertility maps for sustaining soil health and enhancing crop productivity.

MATERIALS AND METHODS

Geographical location of the village

The village Nignoti is about 28 km, towards north of Indore, which is surrounded by Bisenkheda in South, Kadwaliin North, Jagmat Pipliya, inEast and Panod on the Western side. The village is under the administration of - *Gram Panchayat*: Panod, which comes under the block Indore. This block is under the Indore district of Madhya Pradesh state. Both the Panod *Gram Panchayat* and the Indore block offices are located each at a distance of 3 and 28 km, respectively from the village.the total geographical area of the village is 361.23 ha out of which 248 ha area is under cultivation.

Agricultural scenario

Crop husbandry

During rainy season major crop of the village is Soybean which is grown in 95%

area of the village, other kharif crops are Maize, Redgram and fodder. The post rainy season crops are wheat, gram potato, garlic and onion. In summer season, field crops like Greengram and Blackgram are grown and horticultural crops like Coriander and Brinjal are sown. Ground and surface water are used for irrigation purpose. Major area of the village is rainfed and partially irrigated.

Animal husbandry

The village comprises of 88 Buffalo out of which 59 (milk) and 29 (dry). Calves (Female) are 35 (milk) + 25 (dry). Bullocks are 18 and Goats are 22. Indigenous poultry hens are 3. From milch animals milk production is 680 litre/day.

Soil parameters

Soil of experimental site was analyzed for the physico-chemical properties like pH, Electrical conductivity, Organic carbon and available nutrient (N, P, K, S, Zn) and textural classes of soils of study area.

Methods of analysis for assessment of soil fertility

Collection of samples

Soil samples (0-15 cm) at random were collected during May 2013. The soil samples were collected from 15 cm depth with the help of soil auger. The exact sample location was recorded using a GPS. The information on crops was also noted. Processed soil samples were analyzed for nutrient availability by following standard analytical techniques.

Chemical properties

Determination of soil pH

Soil pH was determined in a 1: 2 soil: water suspension by glass electrode Beckman pH meter (Piper, 1950).

Determination of electrical conductivity

The soil suspension used for pH determination was allowed to settle down and conductivity of supernatant liquid was determined by using conductivity meter (Piper, 1950). The results are expressed in dSm-1 at 25ºC.

Determination of organic carbon

Organic carbon content in soil was determined by Walkley and Black's (1934) rapid titration method.

Available nitrogen

It was determine by alkaline permanganate method (Subbiah and Asija, 1956). Twenty gram of soil samples were taken in one litre flask and to it added 100 ml of 0.32% KMnO4 and 2.5% NaOH each. The flask was immediately connected to distillation assembly and heated. The distilled ammonia was collected in 0.1 N H_2SO_4 using methyl red indicator. The excess of sulphur acid was titrated against 0.1 N NaOH. Results have been expressed in N kg/ha.

Available phosphorus

Available phosphorus was determined by using Olsen's extractant (0.5 N sodium bicarbonate solution of pH 8.5, Olsen *et al.*, 1954).

Available potassium

One gram of soil was shaken with 100 ml of neutral normal ammonium acetate solution as an extractant in 200 ml conical flask for 30 minutes and then filtered through Whatman number 40 filter paper. The amount of potassium pre sent in extract was determined by flame photometer as described by Black (1965).

Available sulphur

Available sulphur was determined by the method given by Chesnin, L. and Yien, C. H. (1951).

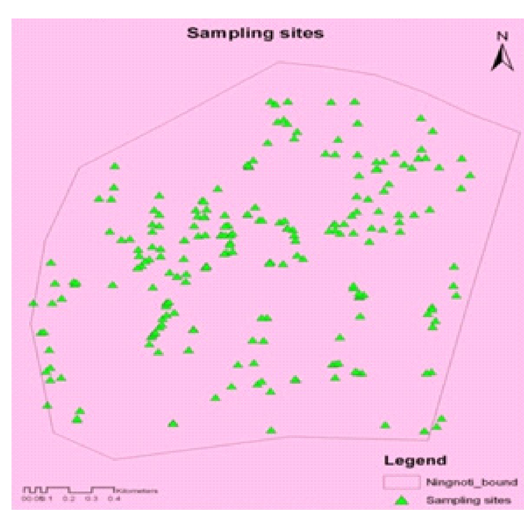
Available micronutrients

The micronutrients Zn, Cu, Fe and Mn were extracted by using 0.005 M diethylene triaminepenta acetic acid, 0.01 M calcium chloride dehydrate and 0.1 m triethanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) and concentrations were analysed by atomic absorption spectrophotometer 4129.

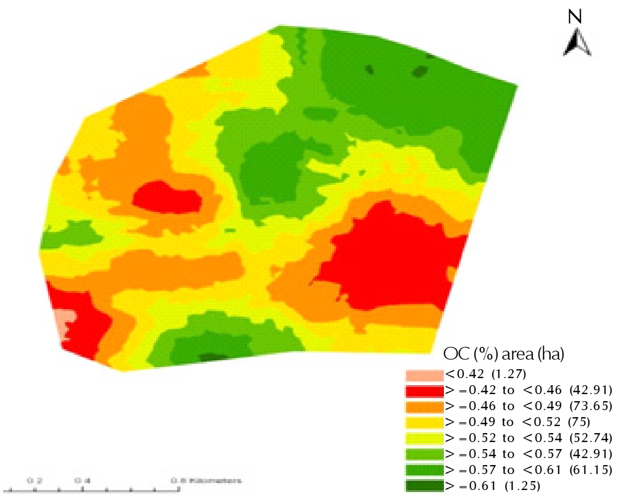
Particle size analysis (mechanical analysis of soil)

Particle size distribution of soil samples was determined by hydrometer method as described by Buoyoucos (1962) using 5%sodium hexametaphosphate as dispersing agent.Particle size distribution of soil samples was determined by international pipette method as described by Piper (1996) using sodium hydroxide as dispersing agent. From the dispersed suspension an aliquot of clay + silt and clay were pipetted out from specified depth at specific time intervals depending on the

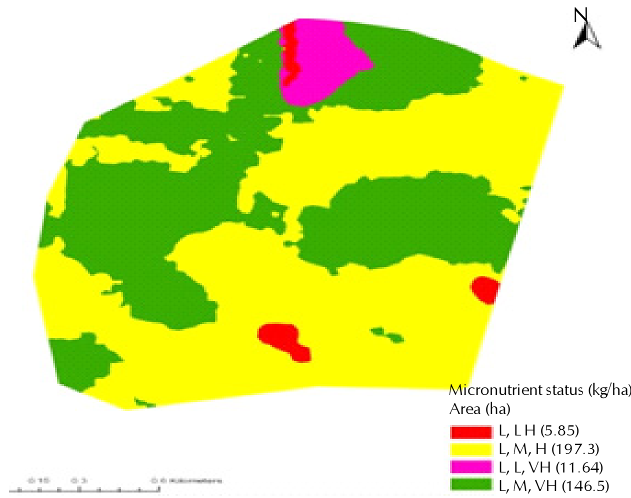
Map 1: Cadastral map of Nignoti village



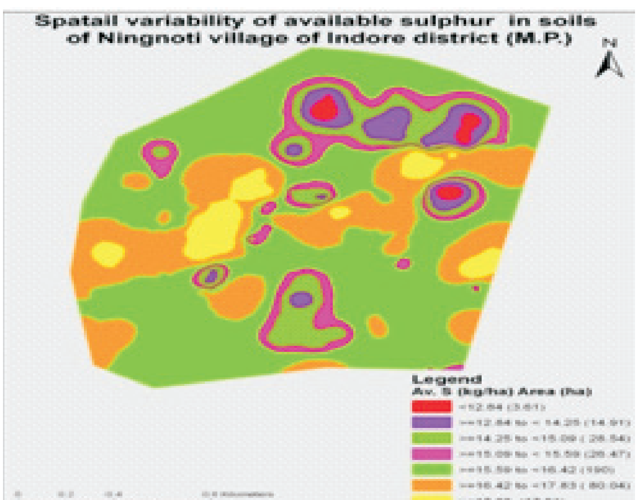
Map 2: Sampling points at village Nignoti



Map 3: Spatial distribution of OC (%) availability classes



Map 4 : Spatial distribution of multi macronutrient status



Map 5: Spatial distribution of Av.-S

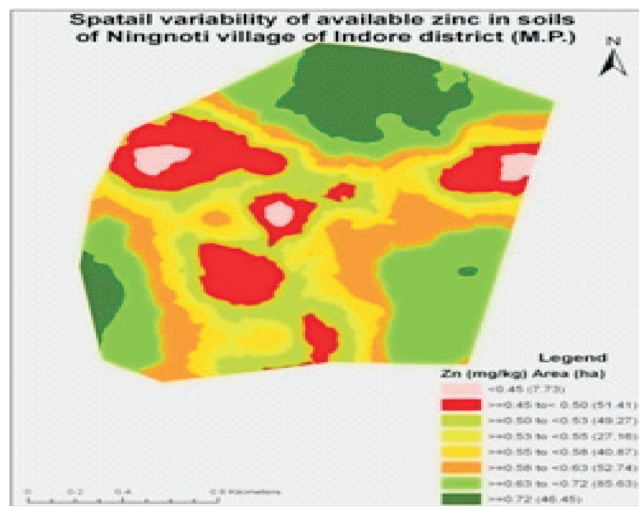


Figure 6: Spatial distribution of Av.-Zn

suspension temperature. The total sand obtained by repeated decantation of silt and clay was passed through 0.05 mm sieve. The fraction that was finer than 0.05 mm was added to silt determined initially by pipetting to have particle size classes as per USDA systems.

Theoretical considerations for preparing spatial pattern maps of soil nutrients

In nature the soil properties are highly variable spatially and for accurate estimation of soil properties these continuous variability should be considered. In recent years a new technique called kriging and its variants were widely recognized as an important spatial interpolation technique in land resource inventories (Henglet *al.*, 2004). The traditional method of soil analysis and interpretation are laborious, time consuming, hence becoming expensive. With the advancement of GIS and remote sensing technology, predictive soil mapping techniques are introduced. Using inexpensive and readily available ancillary data and indicators that reveal a close relationship to specific soil quantities are being used recently for spatial interpolation.

It is fact that soil properties vary from place to place even within the same field. As a result, the spatial structure can vary at scales that differ by several orders of magnitude from a few meters to hundred kilometers. Such variation with distance can be described well with the help of geo-statistics (Carr and Meyers 1984, woodcock *et al.,* 1981, Collin sand woodcock 1999). The above phenomena is the best accomplished by the studying the semivariogram (Warrick *et al.*, 1986) which is a plot of semi-variance that characterizes the rate of change of a mapped variable with respect to distance. Semi-variogramw(h) is computed as half the average squared difference between the soil properties of data pairs. The structure of spatial variability was analyzed through semivariograms. Spatial distribution was analyzed through kriging interpolation using ARCGIS 9.3.1 software. A semivariogram from the set of sample data is calculated using the following equation (Chile' s and Delfiner, 1999):

$$\hat{Y}(h) \quad \frac{1}{2N(h)} \quad {}_{1}^{N(h)}[Z(\quad) \quad Z(\quad h)]^2$$

where N (h) is the number of data pairs separated by lag distance h; z (u5ØüÞ) is measured value of the variable at point a and z (u5ØüÞ+h) is measured sample value at point u5ØüÞ+h.

Parameters

defining semivariogram models are nugget (variability at a smaller scale than the sampling interval and/or sampling and analytical error), sill and range. The range of the semivariogram is defined as the distance at which the variogram stabilizes around a limiting value, the sill, which can be approximated by the total variance of Z(X). The sill expresses the distance (range) beyond which samples are not correlated.

Kriging of geo-statistics is an optimum interpolation technique for making unbiased estimates of regionalized variables at unsampled locations in which the structural properties of the semivariogram and the initial set of samples are used. The spatial prediction of the values of a soil variable Z at an unsampled point X0 is estimated by the formula (Chile' s and Delfiner 1999):

$$Z(X0)^{\ n}_{\ i\ 1} \qquad iZ(Xi)$$

where X denotes the set of spatial coordinates { X1, X2 }, n is the number of neighboring samples and ëi are the weights associated with the sampling points Xi. The predicted value Z(X0) at point X0 is a weighted average of the values Z at n surrounding points.

In the present study the collected cadastral maps were geo-referenced and identified the sites for sampling. Soil samples were collected from 347 sites and their location are recorded through global position system during post-harvest period considering the variations. Spatial variability maps of soil properties was created using the latitude and longitude, the point shape files showing the location of the observation were generated by using ARC Map 9.3.1.

The other parameters like range, mean Standard deviation and coefficient of variation are calculated by classical statistical approach.

Methodology for macronutrients status evaluation

The categorization of the soils of the individual blocks as a whole in to the three fertility classes was done according to the nutrient index values calculated from the soil test summaries giving their percentage distribution into low, medium and high categories.

The nutrient index (Muhr*et al.*, 1965) was given by-

Nutrient index = [% in high category × 3 + % in medium category × 2 + % in low category × 1] / 100

In this percent assessment a nutrient index less than 1.65 denotes low category and that falling between 1.65 and 2.33 represents the medium fertility class. Value of 2.34 and above (maxi 3.00) signifies a high fertility class in respect of the particular nutrient (Ghosh and Hasan , 1976).

The rating of the individual soil test values in to the three classes was performed according to the following limits (Ramamoarhy and Bajaj, 1969) which have been adopted by most of the soil testing laboratories in the country:

Statistical analysis

Geo-statistical analysis was carried-out using Arc 9.2GIS software.

General statistics was calculated by Microsoft Excel.

RESULTS AND DISCUSSION

Soil reaction (pH) and electrical conductivity of soils of Nignoti village

The pH of soils of Nignoti village ranges from 7-8 with a mean value of 7.5, standard deviation 0.183 and coefficient of variation 2.4% (Table 1). Out of 347 soil samples 134 soil samples were neutral in pH and 213 samples were slightly alkaline. Electrical conductivity of soil ranges from 0.11-1.09 dsm-1 with a mean value of 0.38 dsm-1, standard deviation 0.188 and CV% 49.47 (Table 2). Most of the soil samples were normal for total salt concentration. In Nignoti village vertisol soils, pH ranged from neutral to strightly alkaline. High pH in study samples is due to their calcareous nature and the accumulation of bases in the solum as they were poorly

Table 1: Category of soils samples under different soils in Nignoti village

EC dsm-1	No. of Samples	% Samples
<0.1	Nil	Nil
0.1-0.2	7	20.17
0.2-0.3	160	46.10
>0.3	180	51.87
General statistics		
Range	0.11 – 1.09	
Mean	0.38	
Standard deviation	0.188	
CV%	49.47	

Table 2: Electrical conductivity of surface pH rating of Nignoti village

Soil pH class	No. of Samples	% Samples
Strongly acid (<5.0)	Nil	Nil
Moderately acid (5-6.0)	Nil	Nil
Slightly acid (6.1-6.5)	Nil	Nil
Neutral (6.6-7.5)	134	38.61
Slightly alkaline (7.6-8.5)	213	61.38
General statistics		
Range	7.0 – 8.0	
Mean	7.58	
Standard deviation	0.183	
CV%	2.4	

Table 3: Distribution of available -OC status in the soils of Nignoti village

Available-OC (%)	No. of Samples	% Samples
Very Low (<0.25)	2	0.57
Low (0.25-0.50)	19	34.29
Medium (0.50-0.75)	15	61.95
High (>0.75)	11	3.17
General statistics:		
Range (%)	0.23-0.80	
Mean (%)	0.532	
Standard deviation (%)	0.121	
Coefficient of variation (%)	22.74	

Table 4: Extent of area (ha) under different OC

OC- availability class	Available OC%	Area, ha
I	<0.42	1.27
II	>=0.42 to < 0.46	42.91
III	>=0.46 to < 0.49	73.65
IV	>=0.49 to < 0.52	75.00
V	>=0.52 to <0.54	52.74
VI	>=0.54 to < 0.57	53.29
VII	>=0.57 to <0.61	61.15
VIII	>=0.61	1.25

Table 5: Distribution of available nitrogen status in the soils of Nignoti village

Available N (kg ha^{-1})	No. of samples	% samples
Low(<280)	337	97.11
Medium(280-560)	10	2.88
High (>560)	-	-
General statistics		
Range (kg ha^{-1})	114-300	
Mean (kg ha^{-1})	213.46	
Standard deviation (kg ha^{-1})	34.59	
Coefficient of variation (%)	16.20	

Table 6: Distribution of available phosphorus status in the soils of Nignoti village

Available P (kg ha^{-1})	No. of samples	% samples
Low(<12.5)	78	22.47
Medium (12.5-25)	225	64.84
High (>25)	44	12.68
General statistics		
Range (kg ha^{-1})	6.0 - 30.4	
Mean (kg ha^{-1})	17.36	
Standard deviation (kg ha^{-1})	5.82	
Coefficient of variation (%)	33.57	

Table 7: Distribution of available potassium status in the soils of Nignoti village

Available K (kg ha^{-1})	No. of samples	% samples
Low (<135)	-	-
Medium (135-335)	8	2.30
High (>335)	339	97.69
General statistics		
Range (kg ha^{-1})	291-1382	
Mean (kg ha^{-1})	591.35	
Standard deviation (kg ha^{-1})	140.59	
Coefficient of variation (%)	23.77	

leached (Satyanarayana and Biswas, 1970). Similar observations were made by Singh *et al.* (2009) in surface and sub surface soils of district Gajipur Uttar pradesh. Higher pH values were also recorded by Balpande *et al.* (1996) in degrddedVertisols in Purna valley. This increase in soil reaction down the slope could be due to leaching of bases from higher topography and getting deposited at lower elevations (Sitanggang *et al.*, 2006). Where as in C horizon had higher pH which attributed to the accumulation of bases. Similar type of results are reported by Tripathi and Najif *et al.* (2006). Shilpa *et al.* (2007) and singh *et al.* (2009) also reported the similar type of results in soils of U.P. and Maharastra. Electrical conductivity was safe range inNignotivillage., which indicated the black soil pedons were less leached. In Nignotivertisol and associated soils the EC values of the soils ranged from 0.11 to 1.09. In the soils studied, the electrical conductivity generally increased with depths. Similar type of results are reported by Bali *et al.* (2010) and Ved *et al.* (2008) in soils of Panjab and U.P states.

Available organic carbon (Av-OC) status of the soils of Nignoti village

The available organic carbon content (Table 3) of the soils of Nignoti village ranged from 0.23-0.80 %with an average value of 0.53 %. Considering the soil test rating for available - OC (<0.25 as very low, 0.25 - 0.50 as low; 0.50 - 0.75 as medium and >0.75 as high in the status of organic carbon) the soils of Nignoti fall under all the four rating classes of available OC content. In general out of 347 samples, 0.57% samples fall under very low status, 34.2 % samples were categorized under low OC status, 61.95% samples under medium OC status and 3.17 % samples were under high OC status. In this way, about 97% soil samples were low to medium in av-OC status. The general statistics calculated from 347 soil samples revealed that the available OC content ranged from 0.23-0.80 % with a mean value of 0.53%, standard deviation 0.121 % and Coefficient of Variation (CV%) 22.74%. Low organic carbon content in soil may be due to low input of FYM and organic matter,crop residue as well as rapid rate of decomposition due to high temperature, this is the reason for low to medium organic carbon content in these soils. The major proportion of the study area was low to medium in organic carbon (360 ha) Low organic carbon in the soil is due to low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature. The organic matter degradation and removal taken place at faster rate coupled with low vegetation cover thereby leaving less changes of accumulation of organic matter in the soil. High temperature and good aeration in the soil increased the rate of oxidation of organic matter resulting reduction of organic carbon content. Similar results were also noted by Sharma *et al.* (2008) in soil of Amritsar district and Lathwal (2006) in soil of Shahbad&Thaneshwar block. Similar results were also reported by Sharma *et al.* (2008).

Spatial distribution of available-OC in the village soils

Spatial variability map of Av-OC of the village soils is presented in map 1. To prepare the OC variability map soils were divided in to eight categories (Table 4) The spatial variability map of available-OC of Nignoti village (Map4) showed that in whole village the Av-OC content varies from < 0.42 to > 0.61%. It is evident from the map that the maximum area (75 ha) falls under the category IV (>=0.49 to < 0.52 %) followed by category III (>=0.46 to < 0.49 %) 73.65 ha ; Category VII (>=210.33 to >=0.57 to <0.61%) 61.15 ha; category VI (>=0.54 to < 0.57 %) 53.29 ha; category V (>=0.52 to <0.54%) 52.74 ha; category II (>=0.42 to < 0.46 %) 42.91ha, category I (<0.42) 1.27 ha and minimum area under category VIII (>=0.61) 1.25 ha. Out of 361.26 ha area about 360.01 ha area falls under low to medium status of available OC which requires immediate attention to sustain the soil health of Nignoti village.

Available N status of the soils of Nignoti village

Table 8: Extent of spatial distribution of multi macronutrient status

Major nutrient status (kg/ha)			Area (ha)	% area
N	P	K		
L	L	H	5.85	1.62
L	M	H	197.3	54.61
L	L	VH	11.64	3.22
L	M	VH	146.5	40.55

Table 9: Distribution of available sulphur status in the soils of Nignoti village

Available S (kg ha^{-1})	No. of samples	% samples
Low(<20)	265	76.36
Medium (20-40)	82	23.63
High (>40)	-	-
General statistics:		
Range (kg ha^{-1})	5.02-35.66	
Mean (kg ha^{-1})	16.58	
Standard deviation (kg ha^{-1})	4.89	
Coefficient of variation (%)	29.54	

Table 10: Extent of area (ha) under different S availability classes

S - availability class	Available S, kg ha^{-1}	Area, ha
I	<12.84	3.61
II	>=12.84 to <14.25	14.91
III	>=14.25 to <15.09	28.54
IV	>=15.09 to <15.59	26.47
V	>=15.59 to <16.42	190.0
VI	>=16.42 to <17.83	80.04
VII	>=17.83	17.81

Table 11: Distribution of available Zinc status in the soils of Nignoti village

Available Zn (mg kg^{-1})	No. of samples	% samples
Deficient (<0.6)	180	51.87
Sufficient (0.6 – 1.2)	156	44.95
High level (> 1.2)	11	3.17
General statistics:		
Range (mg kg^{-1})	0.2-1.94	
Mean (mg kg^{-1})	0.645	
Standard deviation (mg kg^{-1})	0.268	
Coefficient of variation (%)	41.55	

Table 12: Extent of area (ha) under different Zn availability classes

Zn availability class	Available Zn, kg ha^{-1}	Area, ha
I	I<0.45	7.73 deficient
II	II>=0.45 to <0.50	51.41 deficient
III	>=0.50 to <0.53	49.27 deficient
IV	>=0.53 to <0.55	27.16 deficient
V	>=0.55 to <0.58	40.87 deficient
VI	>=0.58 to <0.63	52.74 deficient/sufficient
VII	>=0.63 to <0.72	85.63 sufficient
VIII	>=0.72s	46.45 sufficient

The available N content (Table 5) of the soils of Nignotivillage ranged from 114 to 300 kg ha^{-1} with an average value of 213.46 kg ha^{-1}. Considering the soil test rating for available N (<280 as low, 280-560 as medium and >560 as high in the status of N) the soils of Nignoti fall under low status (<280 kg ha^{-1}) in available N content. In general out of 347 samples, 97.11% fall under low status and 2.88% samples were categorized under medium N status. In this way, almost all the soil samples tested were found to be deficient in N. The general statistics calculated from 347 soil samples revealed that the available - N content ranged from 114 - 300 kg ha^{-1} with a mean value of 213.46 kg ha-1, standard deviation 34.59 kgha-1 and Coefficient of Variation (CV%) 16.20%.The variation in N status may be related to soil and nutrient management, application of FYM and organics and fertilization pattern of previous crop etc (Ashok Kumar, 2000).

Available P status of the soils of Nignoti village:

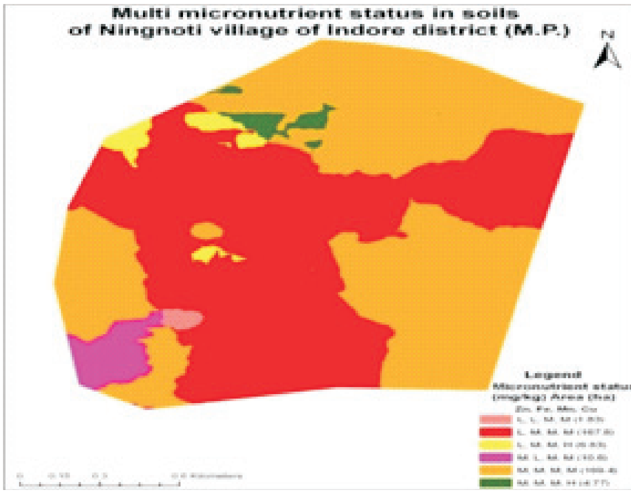
The available P content (Table 6) of the soils of Nignotivillage ranged from 6.0 to 30.40 kg ha^{-1} with an average value of 17.36 kg ha^{-1}. Considering the soil test rating for available p (< 12.5 kg ha^{-1} as low, 12.5 - 25.0 kg ha^{-1} as medium and >25.0 kg ha^{-1} as high in the status of P) the soils of Nignoti fall under low, mediun and high status in available P content. In general out of 347 samples, 22.47% samples fall under low status, 64.84% samples under medium P status and 12.68% samples were high in P status. The general statistics calculated from 347 soil samples revealed that the available - P content ranged from 6.0 - 30.4 kg ha^{-1} with a mean value of 17.36 kg ha-1, standard deviation 5.82 kg ha^{-1} and coefficient of variation (CV%) 33.57%. The variation in available - P is quite large which might be due to variation in soil properties *viz.*, pH, organic matter content, texture and various soil management and agronomic practices adopted by the farmers of the region. Similar results were also reported by Verma*et al.*, 2005.

Available K status of the soils of Nignoti village

The available K content (Table 7) of the soils of Nignotivillage ranged from 291 to 1382 kg ha^{-1} with an average value of 591.35 kg ha^{-1}. Considering the soil test rating for available P (< 135 kg ha^{-1} as low, 135 - 335 kg ha^{-1} as medium and >335 kg ha^{-1} as high in the status of K) the soils of Nignoti fall under medium and high status in available K content. In general out of 347 samples, 2.3% samples fall under medium status and 97.69 % samples were high in K status. The general statistics calculated from 347 soil samples revealed that the available - K content ranged from 291 - 1382 kg ha^{-1} with a mean value of 591.35 kg ha-1, standard deviation 140.59 kg ha^{-1} and coefficient of variation (CV%) 23.77%. Adequate avialble - K in these soils are due to dominance of kaolinite type of clay minerals in vertisols and associated soils. Similar results were observed by Verma *et al.* (2005) in soils of Sardulgarh, Bhikhi and Budhlada blocks and Nirawar *et al.* (2009) in soils of Ahemedpur tahsil of Latur district.

Spatial distribution of multi macronutrient deficiency

Spatial distribution of multi macro nutrient (N, P and K) deficiency is presented in map 4. The extent of area under different categories of macronutrient deficiency is presented in table 8. It is evident from the table that out of 361.23 ha area the extent of area under thecategory of Low N status + Low P status + high K status is 5.85 ha, under Low N + Medium P + high K status the area was 197.3 ha (56.61%), similarly the area under low N + Medium P + very high K status was 146.5 ha and the area under Low N + Low P + very high K



Map 7: Spatial distribution of Multy micro

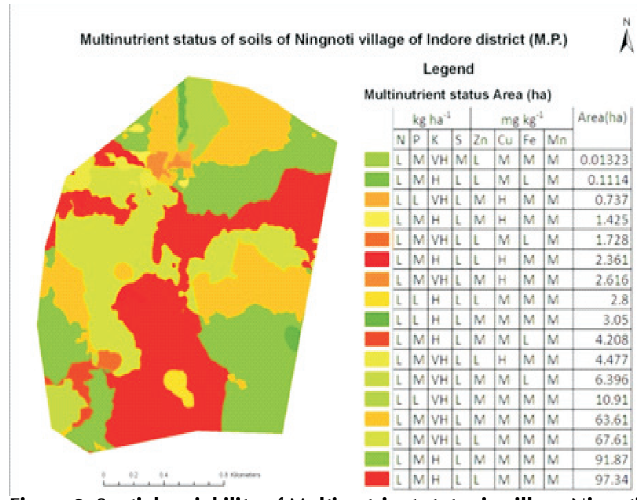


Figure 8: Spatial variability of Multi nutrient status in village Nignoti

Table 13: Extent of Multi micronutrient

Micro nutrient status Zn	Fe	Mn	Cu	Area (ha)	% of total area
L	L	M	M	1.83	0.51
L	M	MM		167.8	46.45
L	M	M	H	6.83	1.89
M	L	M	M	10.6	2.93
M	MMM			169.4	46.90
M	MM	H		4.77	1.32

status was 11.64 ha.Prabhavatiet *al.*2015 also studied the spatial pattern of soil fertility using GIS in three agro-climatic zones of Karnataka and reported similar pattern of macro and micro nutrient variability in these regions.

Available S status of the soils of Nignoti village

The available S content (Table 9) of the soils of Nignoti village ranged from 5.02-35.66 kg ha^{-1} with an average value of 16.58 kg ha^{-1}. Considering the soil test rating for available S (< 20 kg ha^{-1} as low, 20-40 kg ha^{-1} as medium and >40 kg ha^{-1} as high in the status of S) the soils of Nignoti fall under loe and medium status in available S content. In general out of 347 samples, 76.36% samples fall under low status and 23.63% samples were medium in S status. The general statistics calculated from 347 soil samples revealed that the available - S content ranged from 5.02-35.66 kg ha-1 with a mean value of 16.58 kg ha^{-1}, standard deviation 4.89 kg ha^{-1} and Coefficient of Variation (CV%) 29.54%. The low to medium S is partly due to gypsiferrous nature of S which is non available in black soils (Balanagoundar and Satyanarayana, 1990).

Spatial distribution of available-S in the village soils

Spatial variability map of Av-S of the village soils is presented in map 06. To prepare the S variability map soils were divided in to seven categories (Table 10) The spatial variability map of available-S of Nignoti village (map 6) showed that in the whole village the Av-S content varies from < 5.02 to 35.66 kg ha-1. It is evident from the map that the maximum area (190 ha) falls under the category V (>=15.59 to <16.42) followed by category VI (>=16.42 to <17.83) 80.04 ha; category III (>=14.25 to <15.09) 28.54 ha; Category IV (>=15.09 to <15.59) 26.47 ha; category VII (>=17.83) 17.81 ha; category II (>=12.84 to <14.25) 14.91 ha; category VII (>=702.07) 9.26 ha and minimum area under category I (<12.84) 3.61 ha. Soils are low in S mainly due to lack of S addition and continuous removal of S by soybean crop. These soils have gypsum ferrous nature of S which is non-available (Balanagoudar, 1989).Similar results were also reported by Chouhan *et al.* (2012) in the soils ofDewas District in Madhya Pradesh.

Available Zn status of the soils of Nignoti village

The available Zn content (Table 11) of the soils of Nignoti village ranged from 0.2 – 1.94 mg kg^{-1} with an average value of 0.64 mg kg^{-1}. Considering the soil test rating for available Zn (< 0.6 mg kg^{-1} as deficient, 0.6-1.2 mg kg^{-1} as sufficient and >1.2 mg kg^{-1} as high in the status of Zn) the soils of Nignoti fall under deficient, sufficient and high status in available Zn content. In general out of 347 samples, 51.87% samples fall under deficient status, 44.95% samples were sufficient in Zn status and 3.17% samples were high in Zn status. The general statistics calculated from 347 soil samples revealed that the available - Zn content ranged from 0.2-1.94 mg kg^{-1} with a mean value of 0.64 mgkg-1, standard deviation 0.298 mg kg^{-1} and coefficient of variation (CV%) 41.55%. Similar results were also reported by Singh *et al.* (2009) in the soils of Gazipur district of Uttar Pradesh.

Spatial distribution of available Zn in the village soils

Spatial variability map of Av-Zn of the village soils is presented in map 7. To prepare the Zn variability map soils were divided in to eight categories (table 12) The spatial variability map of available-Zn of Nignoti village (map 7) showed that in the whole village the Av-Zn content varies from 0.2-1.94 mg kg^{-1}. It is evident from the map that the maximum area (80.63 ha) falls under the category VII (>=0.63 to <0.72) followed by category VI (>=0.58 to <0.63) 52.74 ha ; category II (>=0.45 to <0.50) 51.41 ha; Category III (>=0.50 to <0.53) 49.27 ha; category VIII (>=0.72s) 46.45 ha; category VI (>=0.55 to <0.58) 40.87 ha; category IV (>=0.53 to <0.55) 27.16 ha and minimum area under category I (< 0.45) 7.73 ha. Out of 361.26 ha total area of the village more than 176.44

ha area is deficient in available- Zn.Vijayashekharet *al.* 2000) also reported similar results for soils which are alkaline in nature.

Spatial distribution of multi micronutrient deficiency in Nignoti Village

The spatial distribution of multi micronutrient deficiency (Zn, Fe, Cu, Mn) in Nignoti village has been shown in map 8. The spatial distribution of the micro nutrient deficiency shows that out of 361.23 ha area 169.4 ha area (46.90%) falls under medium status of Zn, Fe, Mn and Cu, 167.8 ha area (46.45%) has Low Zn status +medium Fe status + medium Mn Status + medium Cu status (Table 13). Similar results were also observed by Sharma *et al.* (2001) in Rajgarh and Narsinghgarh tehsil of M.P. The available iron in surface soils has no regular pattern of distribution as reported by Nayak *et al.* (2002). This type of variation may be due to the soil management practices and cropping pattern adopted by different farmers.

Spatial distribution of multi-nutrient status of soils of Nignoti village

The spatial distribution of multinutrient status of soils of Nignoti village is presented in map 9. It is evident from the map that a multinutreint deficiency has been observed in a considerable area in the Nignoti village. Out of 361.23 ha area 97.34 ha has the status of multi-nutrients as low in N, S, Zn, medium in P, Cu, Fe, Mn and high in K. 91.87 ha area was under Low N, S, medium in P, Zn, Cu, Fe, Mn and high in K status. The spatial distribution map will help in site specific nutrient management to apply the nutrients on the basis of the soil test values in such a way so that one can enhance crop productivity in an economical way while, maintaining the nutrient status of the soil. Similar findings were also reported by Patil *et al.* (2004) in Dharwad district of Karnataka.

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