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Research Article

GPS AND GIS BASED SOIL FERTILITY MAPS OF RANITAL KVK FARM AND IDENTIFICATION OF SOIL RELATED PRODUCTION CONSTRAINTS

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Abstract- A detailed soil fertility status of the Ranital Krishi Vigyan Kendra (KVK) farm was investigated during 2014-15 and soil related crop production constraints were identified for proper utilization of farm land. Total 58 numbers of geo-referenced (GPS based) composite surface soil samples (0-15cm) were collected from 6 blocks of KVK farm located at Ranital in Bhadrak district of Odisha, India. Soils were analyzed for mechanical composition, pH, EC, OC, available N, P, K, S and micronutrients like B, Fe, Mn, Cu, Zn. About 91% soils are found to be loamy sand in nature. Around 41 percent soils are neutral and 59 percent are slightly alkaline in reaction. However, electrical conductivity (EC) remains within safe range for crops (<0.48 dSm^{-1}). SOC varies from 2.3 to 13.7 g kg^{-1} with a mean value of 5.2 g kg^{-1}.The mean available soil N, P, K and S was found to be 106.6, 15.9, 42.69 kg ha^{-1} and 2.34 mg kg^{-1} respectively. The mean hot water extractable Boron, DTPA extractable Fe, Mn, Cu and Zn was found to be 1.14, 29.8. 4.35, 0.93 and 0.16 mg kg^{-1} respectively. Fertilizer recommendation for different crops has been suggested on the basis of soil test values and suitability. Thematic maps were prepared for each soil parameter using ArcGIS package. The soil fertility maps provide the readymade source of information about soil fertility status and serve as the decision making tool for successful raising of field crops and development of orchards.

Keywords- KVK, Ranital, GIS, GPS, soil fertility maps.

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Introduction

The Global Positioning System (GPS) has very wide adaptability in Agriculture in preparation of thematic maps like land use, land cover, soil fertility maps etc. Determination of soil available nutrients status of an area using GPS helps to formulate site-specific nutrient management and to understand the status of soil fertility spatially and temporally. Geographical Information System (GIS) provides valuable support to handle voluminous data, which are generated through conventional and spatial format [1, 2]. GPS and GIS based soil fertility maps have been prepared for different areas of other states [3-4]. Soil fertility database and maps of Odisha have been generated by earlier workers [5- 6] but those are not GPS based. Later on GPS and GIS based soil fertility maps for a few districts of Odisha have been prepared [7-9], but no such work has been done for the farm of KVK, Ranital. Therefore, an attempt has been made in present investigation to prepare GPS and GIS based soil fertility maps for the KVK farm in order to find out the soil fertility related production constraints of the farm and to suggest remedial measures for optimum production of crops.

Experimental site

Ranital Krishi Vigyan Kendra (KVK) in Bhadrak district was established in the year 2004 under Orissa University of Agriculture and Technology (OUAT). The farm is located at 20° 43´N to 22° 11´ N latitude and 82° 39´ E to 85°20°´ E longitude which comes under North Eastern Coastal Plain Zone of Odisha [Fig-1]. The zone is characterized by hot and moist, humid to sub humid climate with hot summer (*Haplaquepts* and *Haplaquents)*. The KVK spreads in an area of 22.4 ha, out of which 15.7 ha of area is cultivable land; about 5 ha land area is waste land and 1.5 ha is covered by infrastructure. The ground water Table ranges from 30 cm to 60 cm. and surface drainage is restricted. This zone is traversed by four major rivers i.e. Subarnarekha in north, Budhabalanga in the centre, Baitarani and Brahmani in the south with their important tributaries i.e. Salandi, Genguti, Mantei and Kharsuan. The nearest tributary to the KVK is Salandi. Major area of the KVK is under irrigation contributed by a branch canal from Salandi irrigation project. The details regarding the climatology, geology and physiography of the site are presented in [Table-1].

Table-1 *Climatology, Geology and physiography of the study area*

1.	Average annual rainfall (mm)	1300 mm
2.	Average annual temperature (°C)	
	(a) Maximum	31.93°C
	(b) Minimum	21.35°C
3.	Average relative humidity	
	(a) Maximum	84%
	(b) Minimum	62%
4.	Climatic classification	Hot and moist, humid to sub humid
5.	Parent material	River alluvium
6.	Height from M.S.L (m)	18 m
7.	Rock system	Pyroxene granite, sand stones, quartzite and lime stone
8.	Physiography	The coastal plains
9.	Type of soil	Alluvial

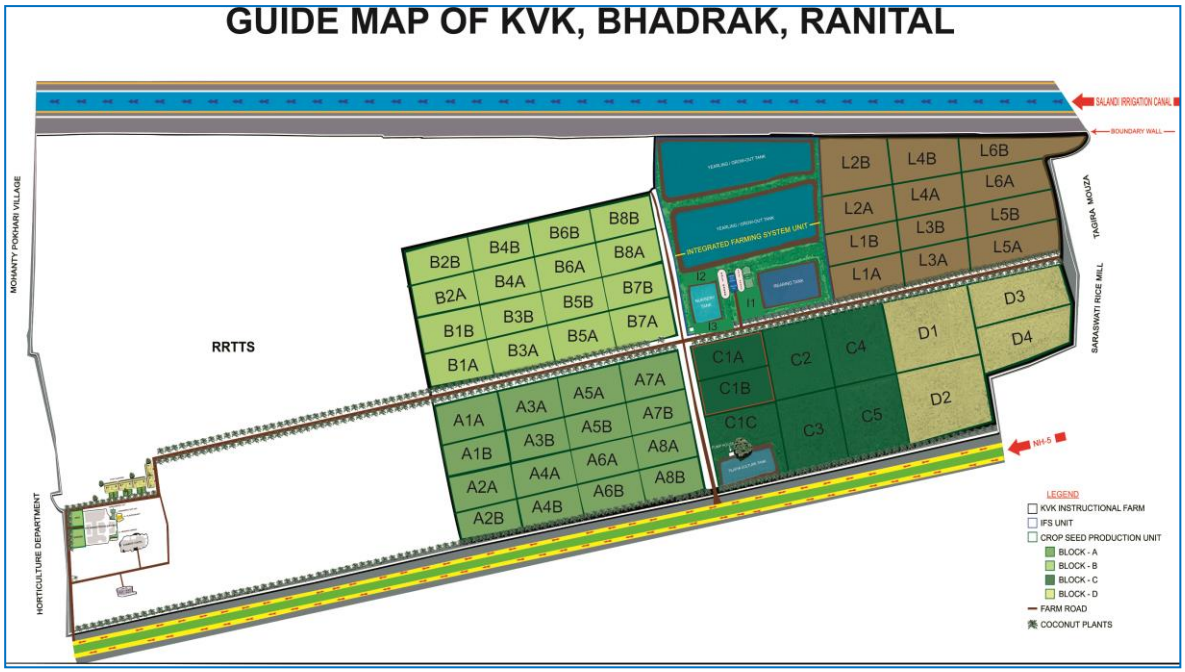

Fig-1 Map of KVK, Ranital

MaterialsandMethods

Altogetherl of 58 numbers of composite surface soil samples were collected from the KVK farm which includes 16 composite samples from each of the blocks A and B; 7, 4, 3, 12 composite soil samples from C, D, I (Integrated Farming System) and L (Low lying area) blocks respectively. The coordination points were recorded by GPS instrument (Garmin76MAPCSx). Soil samples were analyzed for texture [10], pH (1:2), EC (1:2), organic carbon [11], available N [12], available phosphorus [13], available potassium [14], available sulphur [15] hot water soluble Boron [16], DTPA extractable Fe, Mn, Cu and Zinc [17]. Base map of the KVK farm was digitized and geo-referenced. Polygons were superimposed on the geo-referenced map. Latitude, longitude and the data resulted from the soil analysis were entered into attributed Table and processed in ArcGIS software to produce thematic soil fertility maps.

Results and Discussion

Soil Texture

The sand, silt and clay percentage of the farm varies from 61-89, 3.6- 31.2, 4.4 - 11.2% respectively [Fig-2]. Almost all the soils are loamy sand in texture. In some plots i.e. in I_1 and I_2 the soils are sandy loam in texture and the soil of the plot B_2A is sand in texture.

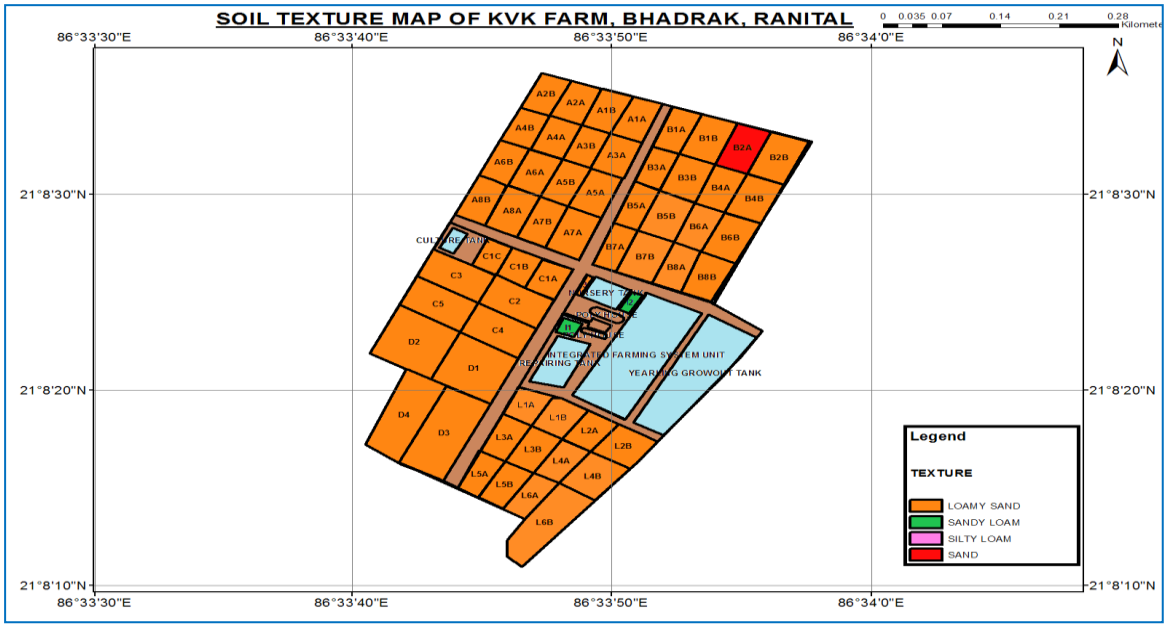

Fig-2 Soil texture map of KVK, Ranital

Soil reaction and Electrical conductivity

The soils are neutral to slightly alkaline (pH 7.01 to 7.98) in reaction for all the blocks. Soils of Block-A, B and C are neutral in reaction with a mean soil pH of 7.57, 7.59 and 7.53 respectively. Soils of Block-D and I are slightly alkaline with a mean soil pH of 7.68 and 7.83 respectively [Table-2] and [Fig-3]. The highest pH was found in plot L1A of Block-L (7.98) and the lowest pH was found in plot L2A of Block- L (pH 7.01). However, this block was found with lowest mean soil pH (7.42) indicating neutral soil reaction. It is revealed that 35.2% of the soils are neutral and 64.8% of the soils are slightly alkaline in reaction. The Electrical conductivity (EC) of all the blocks of the KVK farm remains within safe limit with no salinity hazard [Table-2]. The highest mean electrical conductivity was observed in Block-I (0.261 dSm-1) followed by Block-D (0.107 dSm-1) and the lowest in Block-C

(0.065 dSm-1) which remain within the safe range.

Organic carbon

The mean available organic carbon content of Block-B, D, I and L were 4.9, 0.4.6, 0.3.2 and 4.7 g kg-1 respectively indicating low range of mean organic carbon content; whereas Block-A and C were found medium in mean organic carbon content with 6.0 and 5.7 g kg-1 OC content respectively [Table-2] and [Fig-4]. The data in [Table-2] revealed that both the lowest (2.3 g kg-1) and highest (13.7 g kg-1) organic carbon content was recorded in Block–B. However, 5.4 percent soil of the entire farm is high in organic carbon content. *About* 54.6 percent with medium and 40 percent of the soil are with low OC content. Comparatively lower organic carbon is due of decomposition of organic matter under submerged plots.

Table-2 *pH, Electrical conductivity, Organic carbon content in soils of KVK, Ranital*

Sl No.	Block name	pH		EC (dSm^{-1})		OC (g kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean
1	A (16)	7.4-7.9	7.57	0.05-0.11	0.08	3.7-7.6	6.0
2	B (16)	7.4-7.9	7.59	0.03-0.13	0.07	2.3-13.7	4.9
3	C (7)	7.4-7.7	7.53	0.04-0.09	0.07	4.4-7.1	5.7
4	D (4)	7.7-7.7	7.68	0.09-0.13	0.11	3.3-5.4	4.7
5	I (3)	7.6-7.9	7.83	0.14-0.48	0.26	2.4-3.9	3.3
6	L (12)	7.0-7.9	7.42	0.04-0.10	0.07	3.9-5.9	4.8

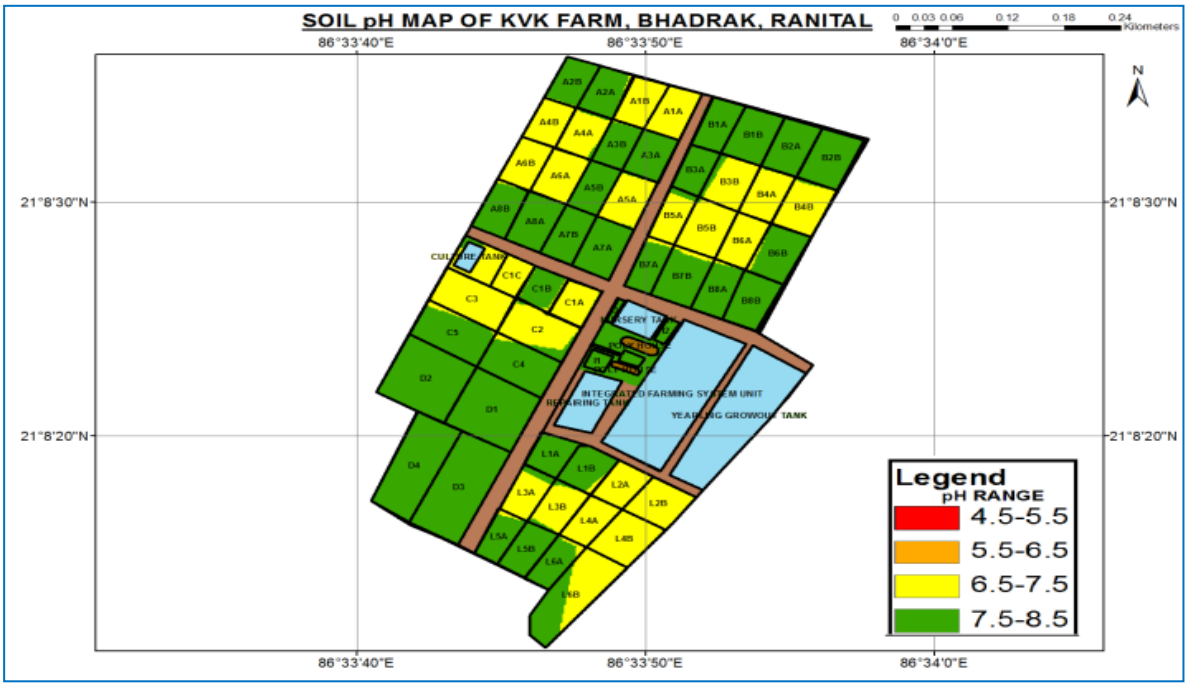

Fig-3 Soil pH map of KVK, Ranital

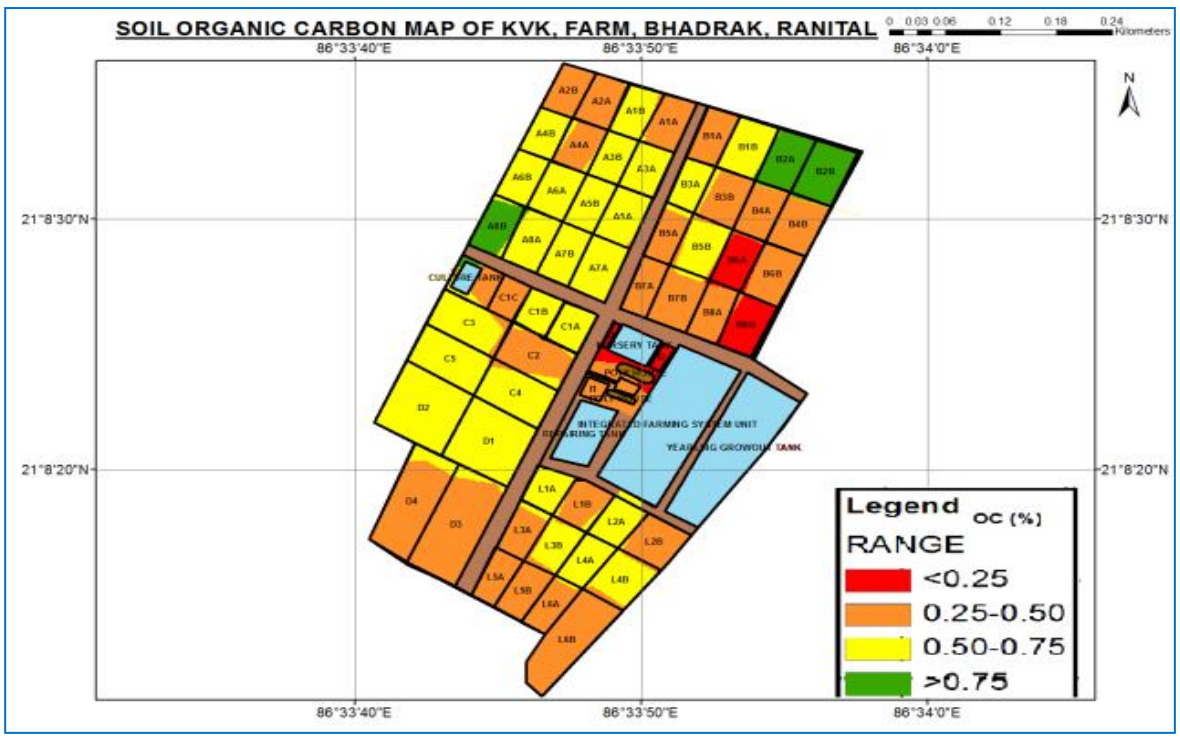

Fig-4 Soil organic carbon map of KVK, Ranital

Available Macronutrients

Soils are deficient in available nitrogen [Table-3] and [Fig-5] due to crop removal and various nitrogen losses. Mean available soil nitrogen of Block-C is comparatively higher than other blocks (120.7 kg ha-1) followed by Block-D (118.6 kg ha-1), Block-B (114.5 kg ha-1), Block-L (102.6 kg ha-1). Block-I contains the lowest mean available nitrogen (71.1 kg ha-1). However, the lowest available soil nitrogen content was recorded in Block-A (62.7 kg ha-1) with a mean value of 99.5 kg ha-1 and highest available nitrogen was found in Block-B (150.5 kg ha-1). Block-A, B, C, D and L of the farm are medium in mean available soil Phosphorus representing 16.4 kg ha-1, 13.9 kg ha-1, 15.9 kg ha-1, 20.6 kg ha-1 and 15.0 kg ha-1 respectively while Block-I contains high mean available phosphorus (22.4 kg ha-1) [Table-3] and [Fig-6]. The highest available phosphorus was found in Block C (28.6 kg ha-1) whereas, the lowest available phosphorus content was recorded in Block-B (8.1 kg ha-1 [Table-3]. However, 85 percent soil of the farm are medium in available phosphorus content (Olsen's P), 13 percent soils are high in available phosphorus content whereas, 2 percent of soils are low in available phosphorus. It may be due to regular application of phosphate fertilizers in the farm. The mean available soil potassium of all the blocks was low except Block-I. The highest available potassium (196 kg ha-1) was found in Block-I whereas, lowest potassium content (21.3 kg ha-1) was recorded in Block-A [Table-3] and [Fig-7]. Around 92.3% soils of the farm are low while 7.7% of the soils are medium range in available potassium. The low availability of this element is due to low clay content of soil and crop uptake.The available soil sulphur of the farm is very low which may be due to crop uptake in rice based cropping system. The highest available soil sulphur (4.88 kg ha-1) was found in Block-A while lowest amount of sulphur (0.6 kg ha-1) was recorded in Block-B [Table-3] and [Fig-8].

Table-3 *Available macronutrient content in soils of KVK, Ranital*

Sl No.	Block	Av. N (kg ha^{-1})		Av. P (kg ha^{-1})		Av. K (kg ha^{-1})		S (mg kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	A	62.7-112.9	99.5	9.4-25.2	16.4	21.3-34.7	25.9	1.6-4.9	2.9
2	B	87.8-150.5	114.5	8.1-24.2	13.9	22.4-50.4	32.3	0.6-4.7	2.6
3	C	112.9-142.5	120.7	9.4-28.6	15.9	25.8-51.2	38.5	0.8-3.3	1.7
4	D	100.4-138.0	118.6	16.8-25.9	20.6	62.7-125.4	95.1	1.9-2.6	2.2
5	I	50.2-87.8	71.1	15.80-27.2	22.4	126.2-196	152.1	0.9-3.6	2.4
6	L	64.1-125.4	102.6	11.4-19.2	15.0	25.8-52.6	36.5	1.1-3.5	2.2

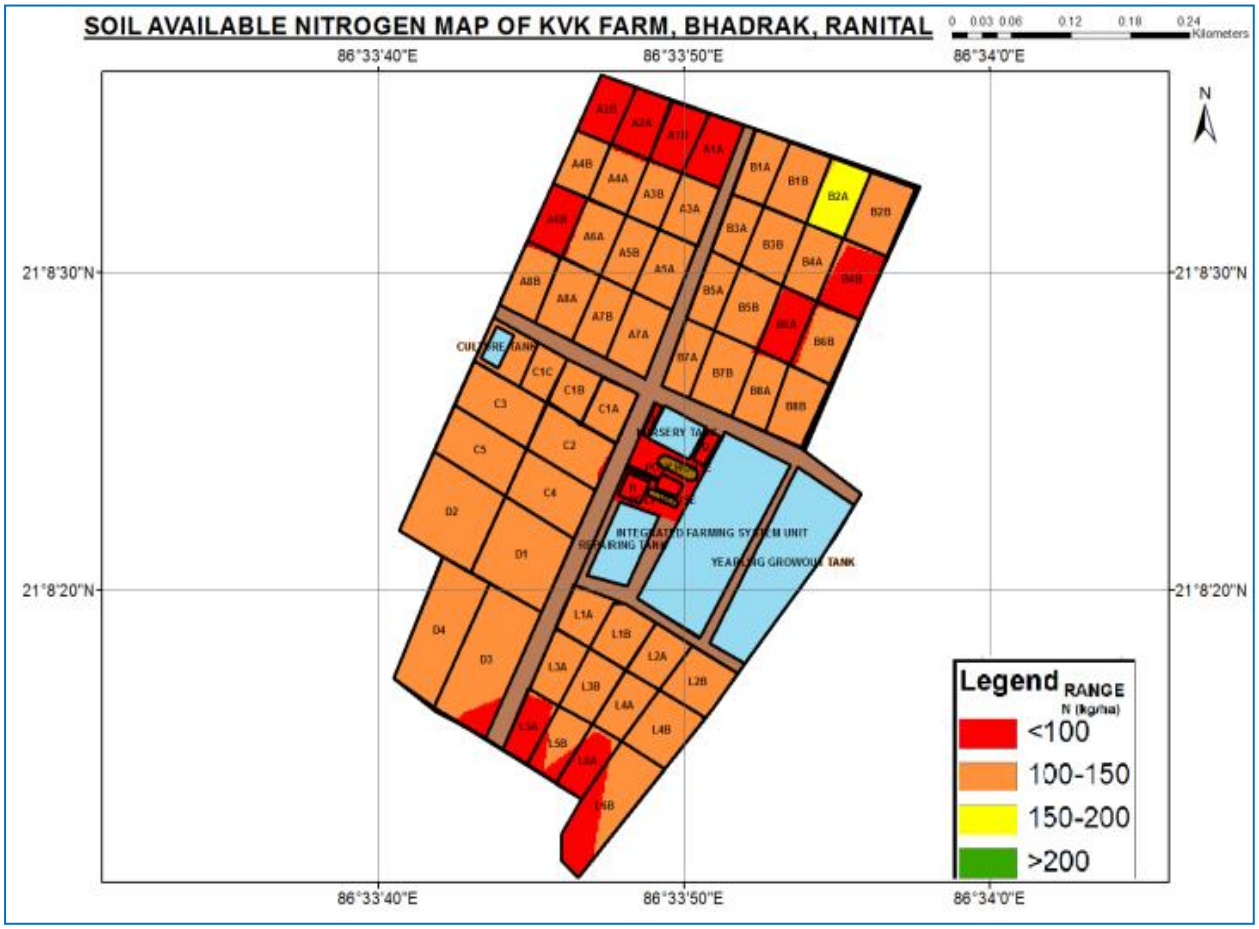

Fig-5 Soil available nitrogen map of KVK, Ranital

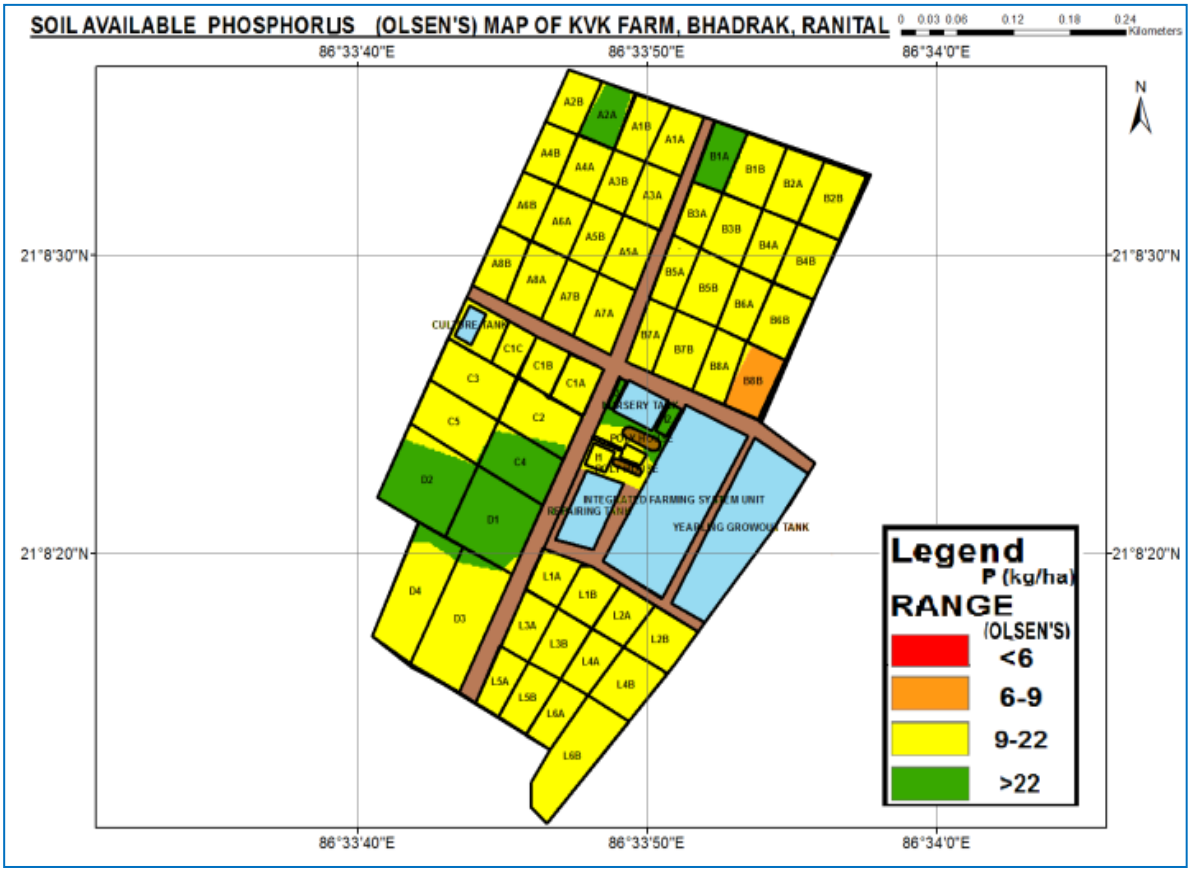

Fig-6 Soil available phosphorus map of KVK, Ranital

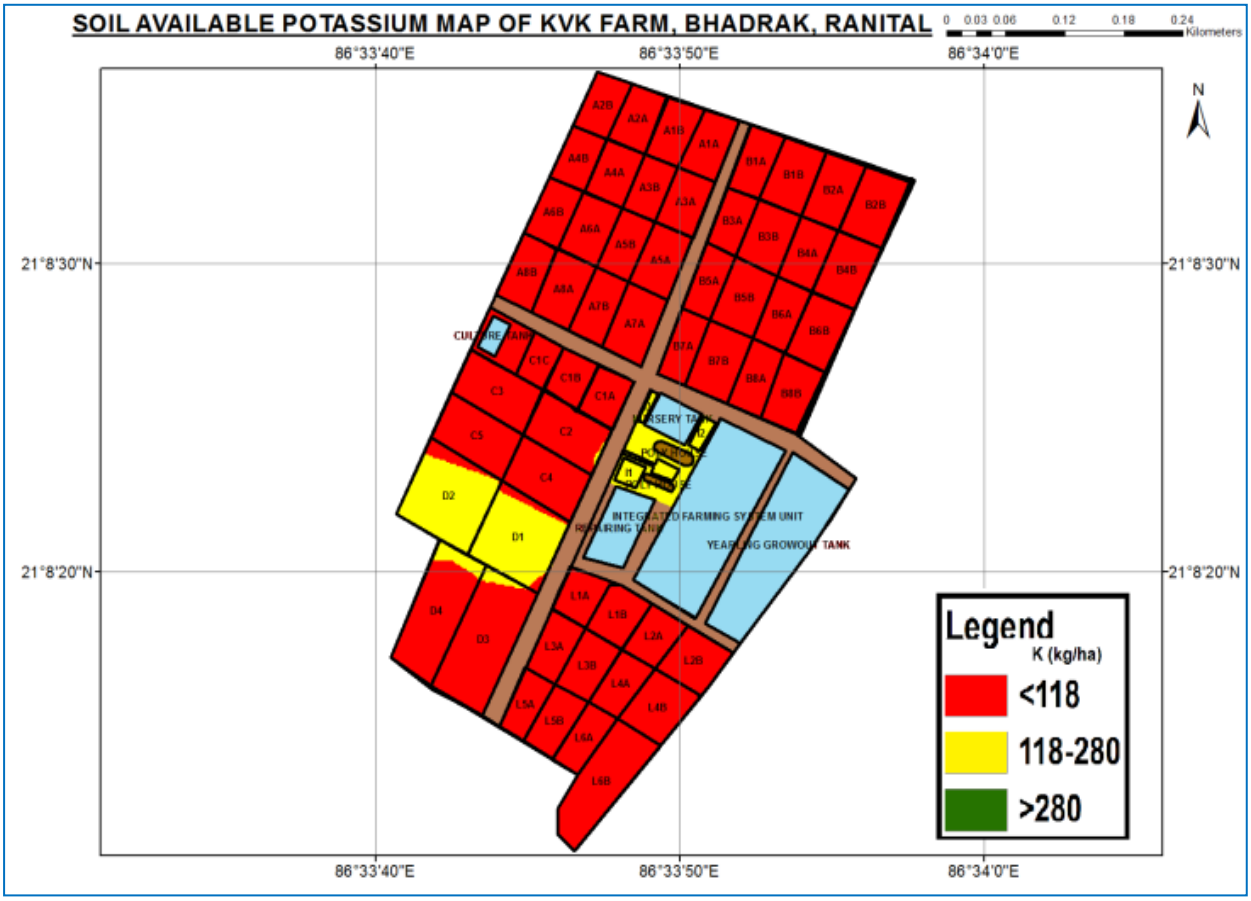

Fig-7 Soil available potassium map of KVK, Ranital

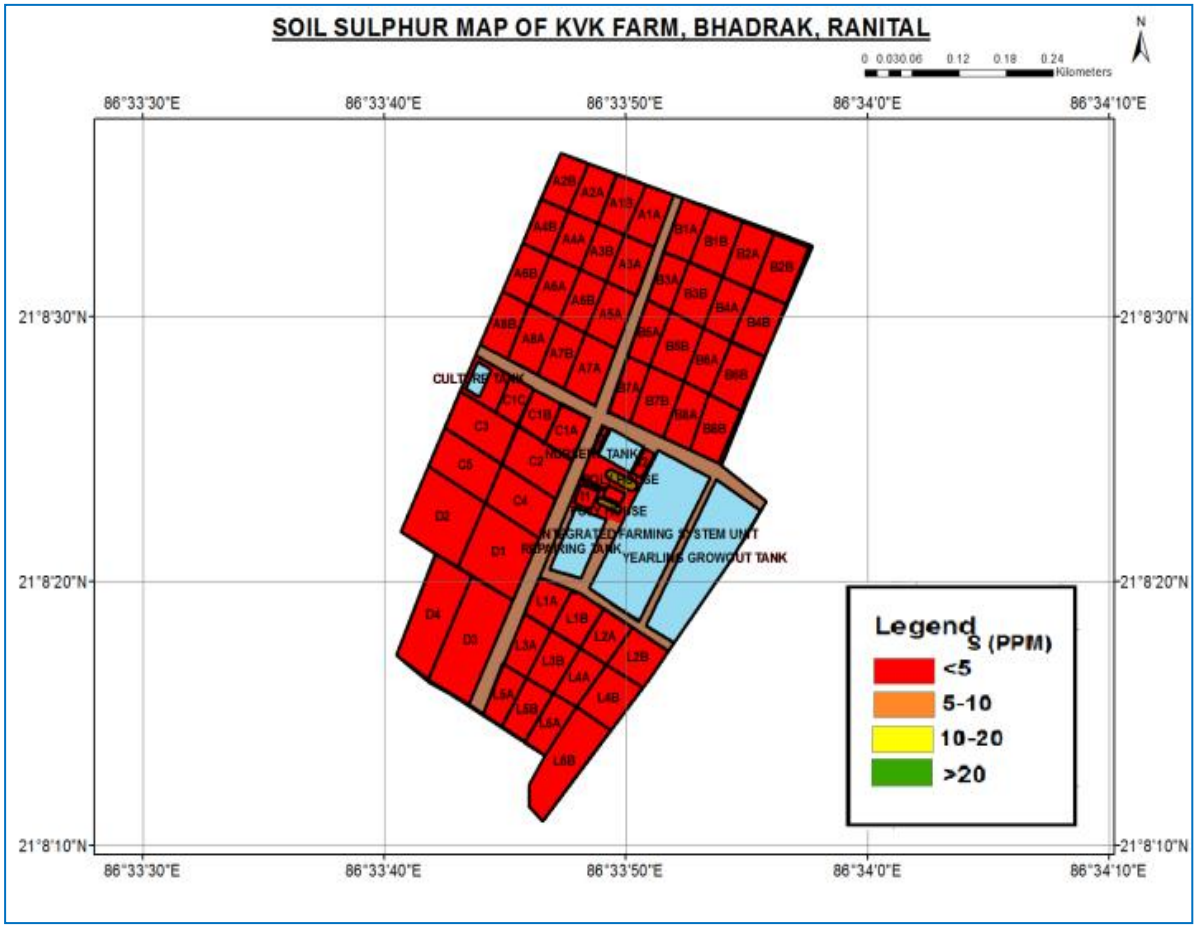

Fig-8 Soil available sulphur map of KVK, Ranital

Available Micronutrients

It was observed that even though soil reaction of the farm is neutral to slightly alkaline, the DTPA extractable iron and manganese content of the farm is very high up to 41.60 mg kg-1 and 7.11 mg kg-1 respectively against the critical level 4 mg kg-1 for iron and 1.0 mg kg-1 for manganese [Table-4] and [Fig-9 & 10]. The high values of Fe and Mn may be explained as the soils of Ranital have been formed from river alluvium and are classified as Typic Haplaquepts and Aeric Haplaquents consist of the sediments which are originated from the weathered product of a rock system belonging mainly to the Iron ore series containing garnetiferous gneiss, schist and rocks of Singhbhum granites. Similar observation has also been reported earlier by Mishra [18]. DTPA extractable zinc remains below the critical limit (<0.6 mg kg-1) in all the blocks [Table-4] and [Fig-11]. Low availability of zinc in soil is due to pH higher than 6.0 [19]. The mean DTPA extractable copper content of all the blocks was above critical limit [Table-4] and [Fig-12]. However, it is reflected in the maps that 5.8% soil of the farm are low in available copper content (< 0.2 mg kg-1) [Table-4] while 94.2% soils of Block-A, D, a major part of Block-B, L and a small part of Block-C are above critical limit (>0.2 mg kg-1). Again, the mean hot water soluble boron was found to be remained above the critical limit (>0.5 mg kg-1) [Table-4] and [Fig-13] which covers 87 percent of the farm land.

Table-4 *Available micronutrient content in soils of KVK, Ranital*

Sl No.	Block	Fe (mg kg^{-1})		Mn (mg kg^{-1})		Cu (mg kg^{-1})		Zn (mg kg^{-1})		B (mg kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	A	31.2-41.6	35.96	1.30-4.44	2.54	0.82-1.20	0.93	0.14-0.35	0.19	0.56-1.57	1.13
2	B	33.9-39.8	36.63	1.96-6.92	4.46	0.12-1.28	0.85	0.09-0.40	0.18	0.22-2.69	0.80
3	C	24.2-38.2	32.56	4.78-7.11	5.94	0.02-1.24	0.73	0.10-0.24	0.16	0.28-1.68	1.10
4	D	18.8-23.6	21.15	4.46-5.88	5.22	0.94-1.08	1.02	0.08-0.15	0.11	0.89-1.56	1.22
5	I	32.2-40.6	35.27	2.80-6.16	4.86	0.13-1.24	0.54	0.18-0.29	0.22	1.12-1.78	1.52
6	L	4.9-39.7	20.25	1.32-6.16	3.06	0.10-1.10	0.83	0.03-0.17	0.12	0.28-2.91	1.50

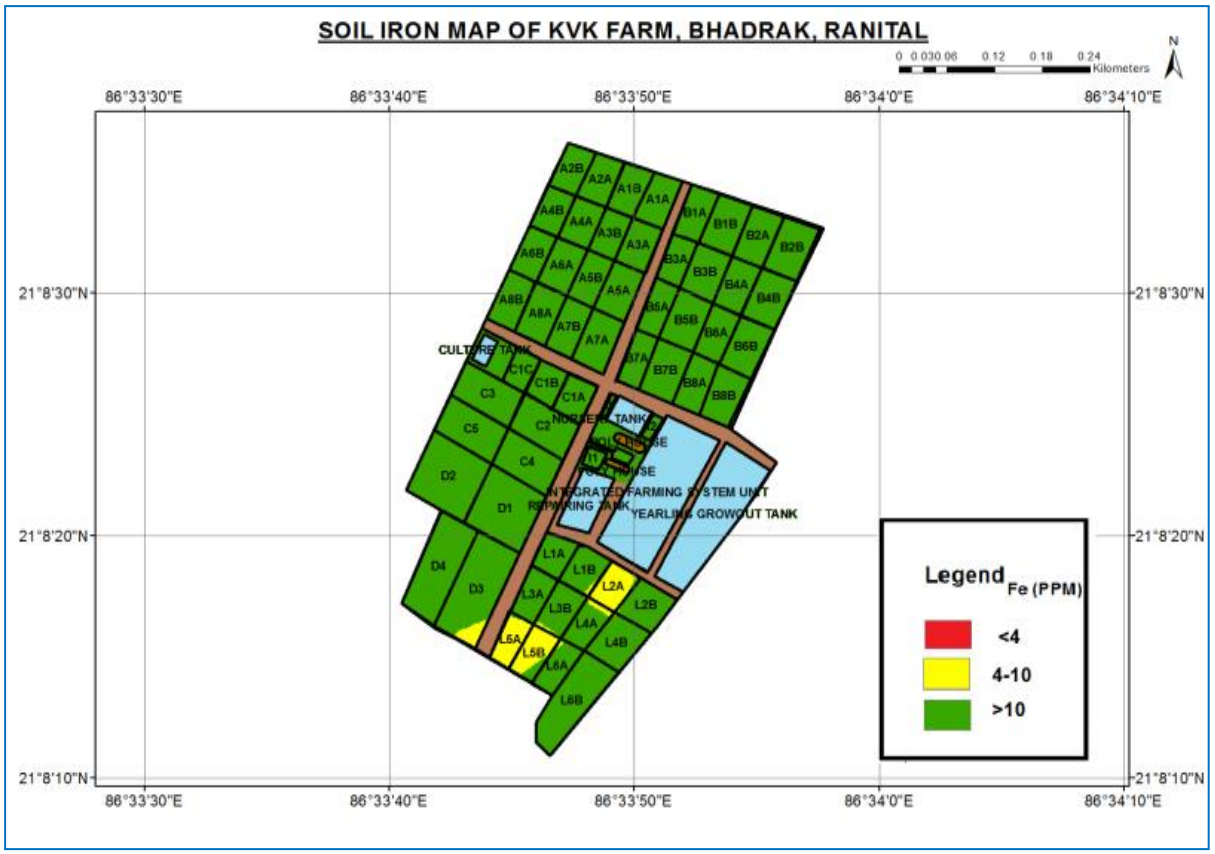

Fig-9 Soil available iron map of KVK, Ranital

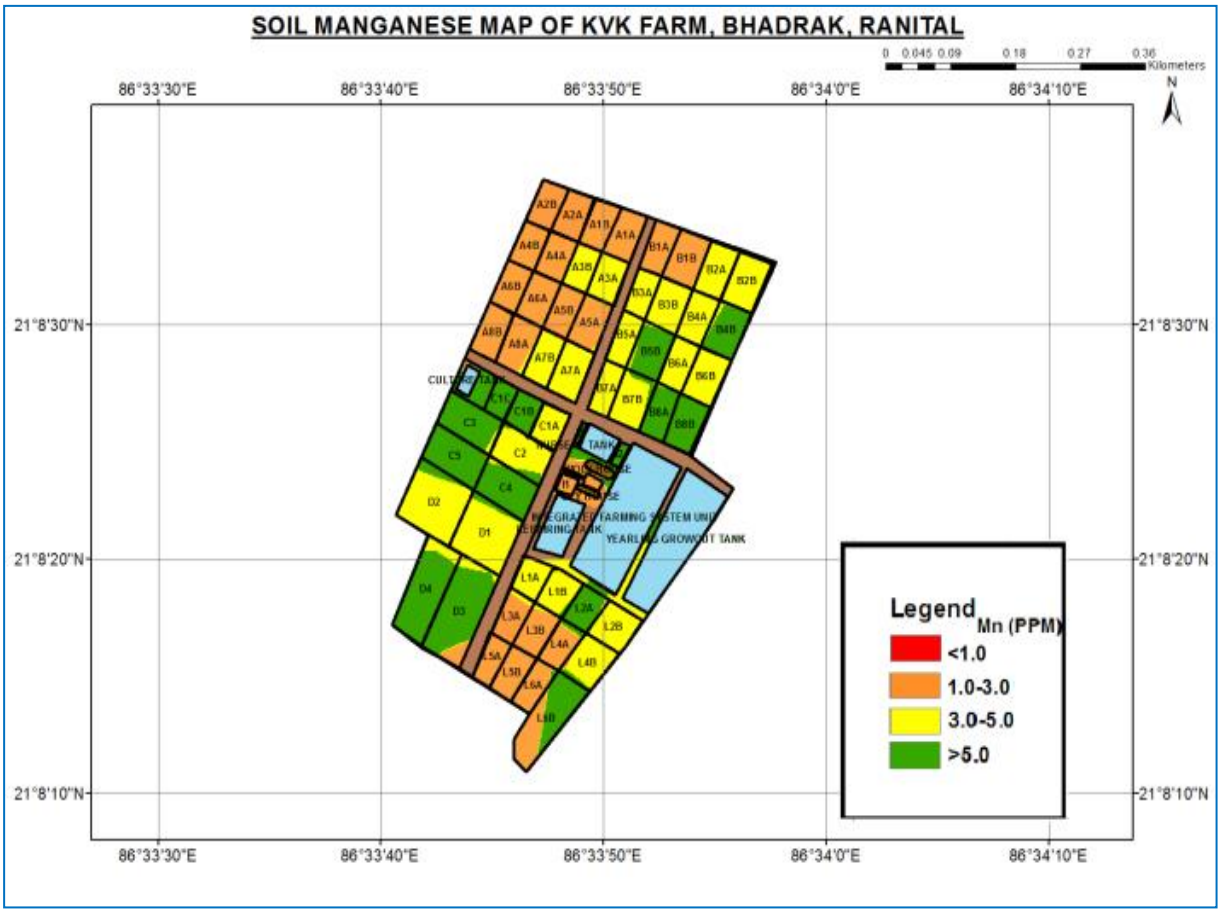

Fig-10 Soil available manganese map of KVK, Ranital

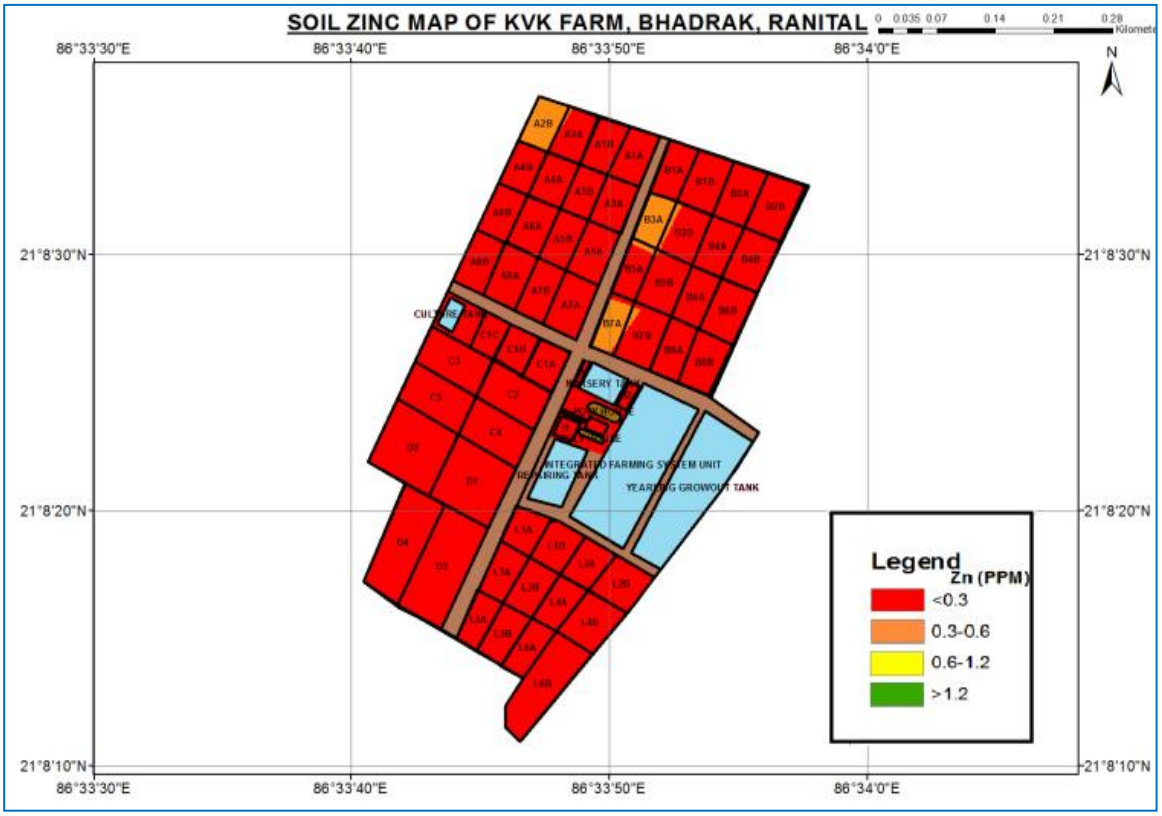

Fig-11 Soil available zinc map of KVK, Ranital

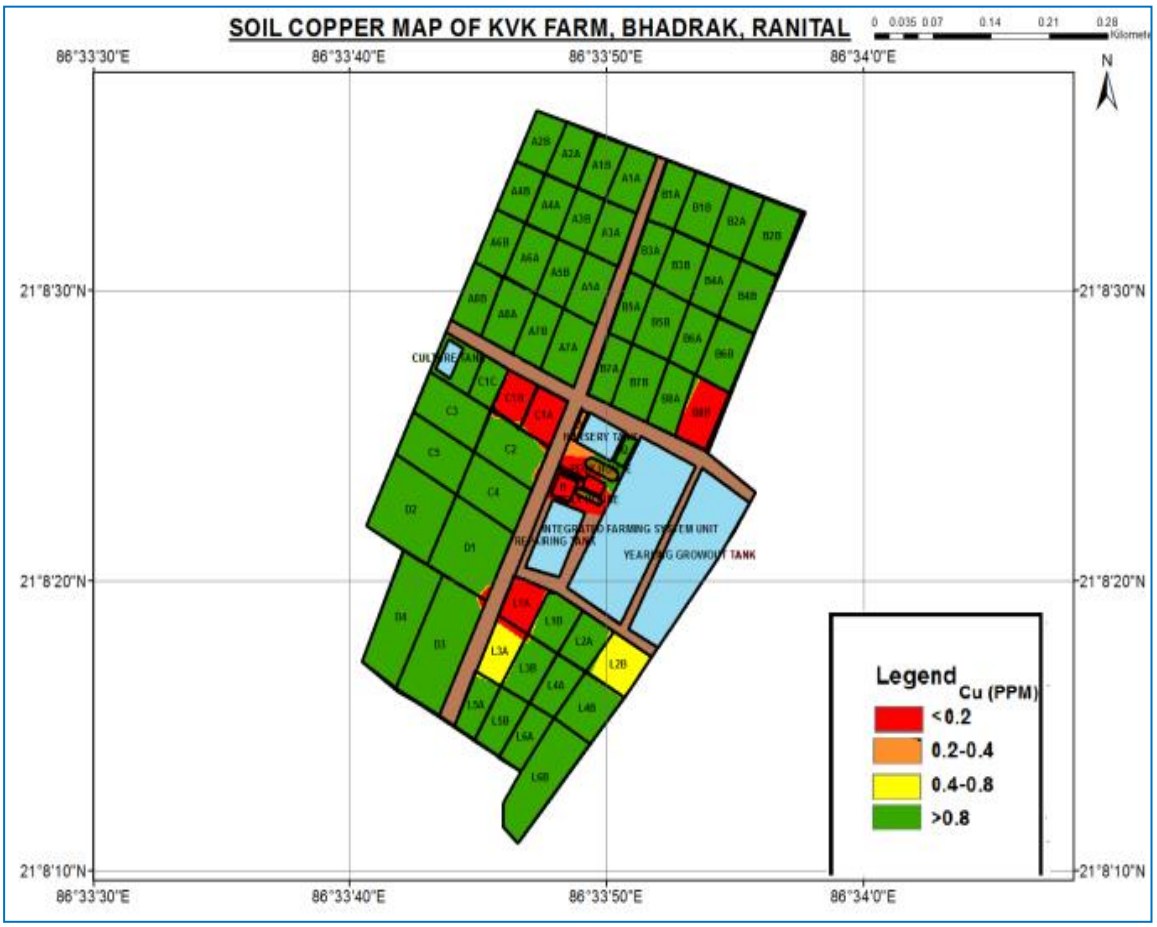

Fig-12 Soil available copper map of KVK, Ranital

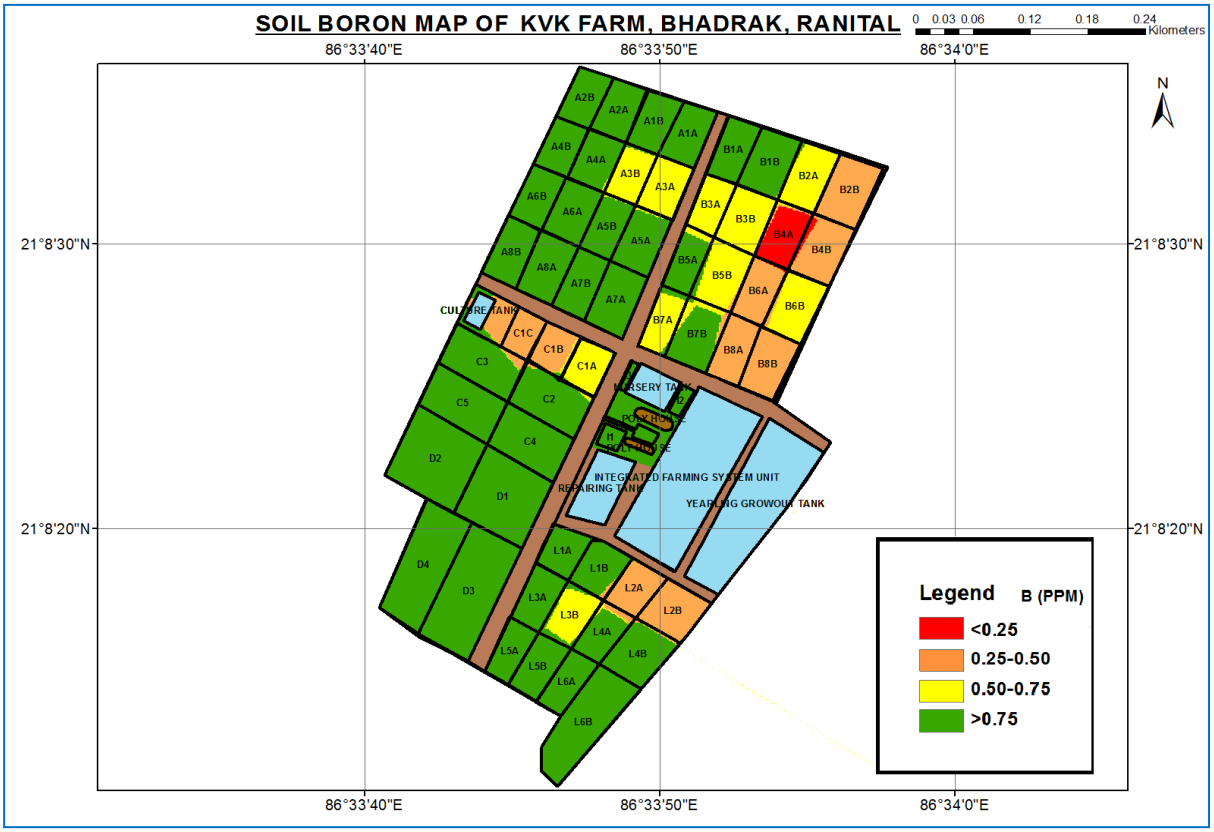

Fig-13 Soil available Boron map of KVK, Ranital

Recommendations

A balanced fertilizer recommendation can be prepared for various crops based on the available soil nutrient status found by the survey and analysis of GPS based soil samples collected from various plots of the farm. Considering major nutrients i.e. available nitrogen, phosphorus and potassium; 25% more than the recommended dose of fertilizer for a crop in interest can be applied in the plots where the available soil nutrient is low. In case of high status of a nutrient in a plot, 25% less than the recommended dose of fertilizer can be given. When the nutrient content of a plot lies in medium range, the recommended dose of fertilizer is to be given [20]. All the plots of this farm are low in available sulphur content therefore, sulphur containing fertilizers, gypsum, phospho-gypsum can be applied according to the crop grown .i.e. sulphur is recommended for paddy, pulses, oilseed and vegetables (hybrids) at the rate of 20, 30, 40 to 45 kg ha-1 respectively. Zinc sulphate can be applied in proper doses depending on the crops grown in the farm as all the plots of the farm are zinc deficient. As zinc deficiency is a common problem in paddy, 2.0 kg ha-1 Zn or 12.5 kg ha-1 $ZnSO_4$ is recommended to overcome the deficiency. Likewise, boron in the form of borax can be applied in proper doses in vegetable crops, as boron deficiency is common in vegetables. In deficient soil, 1.0 kg ha-1 Boron or 10 kg ha-1 Borax can be recommended.

Conclusion

Soil properties are different within the KVK farm. It prioritizes the importance of mapping of different soil fertility parameters over the usual practice of assessing soil fertility on the basis of mean values of the concerned parameters. The use of GPS instrument and GIS package for collection of soil samples and preparation of soil fertility maps of KVK, Ranital will help the local farming community in many ways. It will help in monitoring soil health from time to time by bringing soil samples from the same spots from which the samples are drawn in present investigation. By collecting and analyzing the geo-referenced soil samples at intervals, the change in soil fertility status can be monitored and remedial measures can also be suggested to maintain soil health for sustainable crop production. This work can be extended in other KVKs of Odisha for monitoring soil health and achieving higher crop production.

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List of Abbreviation:

GPS-Global Positioning System; GIS - Geographic information system; KVK-Krishi Vigyan Kendra

Conflict of Interest: None declared

References

[1] Rao A.S. and Srivastav S. (1999) *Fertilizer News,* 44 (4), 89-95.
[2] Vadivelu S. (2007) *Proceedings of National Symposium on Soil Science Research, Indian Society of soil Science,* Kolkata, Dec. 7-9, pp 31-35.
[3] Sharma P.K., Sood A., Setia R. K., Verma V. K. (2008) *Journal of Indian society of Soil science,* 56, 34 – 41.
[4] Muralidharudu Y., Reddy S.K., Mandal B.N., Rao A.S, Singh K.N. and Sonekar S. (2001) *GIS based soil fertility maps of different states of India. All India Coordinated Research Project on soil test crop response correlation*, Indian Institute of Soil Science (ICAR), Bhopal.
[5] Mitra G.N., Mishra U.K. and Sahu S.K. (2002) *Macro and Micronutrient status of the soils of Orissa, Dept. of Agriculture*, Govt. of Orissa.
[6] Nanda S.K, Mishra A., Pradhan N.K., Muralidharudu Y. (2008) *Soil testing and fertilizer recommendation in Orissa*, All India Coordinated research project on Soil Test Crop Response Co-relation, Dept. of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar, pp.26-31.
[7] Mishra A., Das D. and Saren S. (2013) *Indian Agriculturist,* 57 (1), 11-20.
[8] Mishra A. and Pattnaik T., Das D. and Das M. (2014) *International Journal of Plant and Soil Science,* 3 (8), 986-994.
[9] Mishra A., Saren S., Das D. and Dey P. (2016) *Annals of Plant and Soil Research*, 18(1), 23-28.
[10] Bouyoucos G. J. (1962) *Agronomy Journal,* 54, 464.

[11] Walkley A. J. and Black I.A. (1934) *Soil Science,* 37, 29-38.
[12] Subbiah B.V. and Asija G.L. (1956) *Current Science*, 31, 196.
[13] Olsen S.R., Sommers L.E. (1982) *Method of Soil Analysis* (A.L. Page *et al.,* Eds.). Part 2, 2nd Edition, 403-430. Madison, Wisconsin. American Society of Agronomy and Soil Science Society of America.
[14] Hanway J.J. and Heidel H. (1952) *Iowa Agric*., 57, 1-31.
[15] Chesnin L. and Yien C.H. (1950) *Soil Science Society of America Proceedings*, 14, 149-151.
[16] John M.K., Chuah H.H. and Ndufeld J.H. (1975) *Ann. Lett.,* 8, 559-568.
[17] Lindsay W. L. and Norvell W. A. (1978) *Soil science society of America Journal,* 42, 421-428.
[18] Mishra K. N. (1993) *M.Sc (Ag) Thesis*, Dept. of Soil Science, O.U.A.T, Bhubaneswar.
[19] Thorne W. (1957) *Adv. Agron*, 9, 31-65.
[20] Mitra G. N., Sahoo D. and Sahu G.C. (1980) *Laboratory manual of soil and water testing*. *Directorate of Agriculture and Food Production, Orissa and Dept. of Soil and Agril. Chemistry, OUAT,* Bhubaneswar.