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GPS and GIS based soil fertility maps of KVK farm, Nayagarh located in the North-Eastern Ghat Agro-Climatic zone of Odisha, India

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Abstract
Surface soil samples were collected from upland (10 number of samples), medium land (10 number of samples) and low land (10 number of samples) of KVK, Nayagarh Farm. In upland, medium land and low land surface soils average sand percentage were found to be 84.4, 81.5 and 76.94; while average silt percentage was 4.65, 5.58 and 6.04 respectively and average clay percentage was found to be 10.68, 12.38 and 17.02 respectively; average pH value were found to be 4.59, 5.55 and 5.62 respectively; While average soil OC values were found to be 4.07, 5.22 and 5.66 g/kg respectively. Average soil available N of upland, medium land and low land were found to be 135.5, 167.2 and 200.7 kg/ha respectively. Average soil available P of upland, medium land and low land were found to be 10.2, 10.4 and 15.3 kg/ha respectively. Average soil available K of upland, medium land and low land were found to be 195.6, 260.4 and 311.5 kg/ha respectively. Soil available S of upland, medium land and low land were found to vary between 2.56 to 4.86, 3.22 to 5.26 and 4.10 to 6.02 mg/kg with a mean value of 3.46, 4.21 and 5.29 mg/kg respectively. Soil available boron of upland, medium land and low land were found to vary between 0.45 to 0.75, 0.55 to 0.90 and 0.61 to 0.95 mg/kg with a mean value of 0.58, 0.73 and 0.75 mg/kg respectively. Results shows that a gradual increase in available N, P, K, S and B was found from upland to towards low land surface soil which could be attributed to increase in organic matter and clay content in the low land.

Keywords: GPS, GIS, KVK, Nayagarh, soil fertility maps, Odisha

Introduction

The Global Positioning System (GPS), a space-based satellite navigation system that provides weather condition and location, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites has helped enormously to the delineation programmed. With the help of GPS spatial variability of soil properties were measured and maps were developed accordingly to be used by planner and farmers. The advent of information technology have provided tools like global positioning system (GPS), geographical information system (GIS) which helps in collecting a systematic set of georeferenced samples and generating the spatial data about the distribution of nutrients. The maps generated through remote sensing helps in delineating the homogenous units to decide the sampling size and thereby saving a lot of time. This will also help to monitor the changes in nutrient status over a period of time as georeferenced sampling sites can be revisited with the help of GPS which is otherwise difficult in the random sampling (Sood *et al.* 2004) [14]. The study area is being used for research trials, But, ever not done the GPS-GIS based soil fertility status of the farm. Since any systematic soil survey of this area has not yet been done, therefore, an attempt has been made in the present investigation to prepare GPS and GIS based soil fertility maps of KVK farm of Nayagarh.

Materials and method

Surface soil samples were collected from upland (10 number of samples), medium land (10 number of samples) and low land (10 number of samples) of KVK, Nayagarh Farm by using Global Positioning System (GPS) (Garmin MAKE; model: 76MAPCSx) followed by analysis of physico-chemical properties and maps were prepared subsequently. The GPS instrument receives data from at least 4 satellites to record correctly the latitude and longitude of the place.

The soil samples collected from soil surface were air dried, ground with a wooden hammer and passed through 2 mm sieve. The samples were then preserved in plastic bottles, labelled and stored for laboratory studies. Soils were analysed for textural class by Bouyoucos Hydrometer method (Piper, 1950) [10], pH (1:2), EC (1:2), organic carbon Walkley and Black method (Jackson, 1973) [5], available nitrogen (Subbiah and Asija, 1956) [15], phosphorus (Bray and Kurtz, 1945) [1], potassium (Hanway and Heidel, 1952) [4], sulphur (Chesnin and Yien, 1950) [2] and hot water extractable Boron (Jackson, 1973) [5]. Base map of the study area was geo-referenced and digitized. Latitude, Longitude and soil analysis data were entered into attributed table and linked to Arc GIS software for making thematic soil fertility maps.

Results and discussion

Soil textural class, soil reaction, Electrical Conductivity, Organic Carbon content and available N, P, K, S and B are presented in table no. 1 and comparison of mean values of upland medium land low land are prasented in table no. 2

Soil textural class

The upland soils have sand, silt and clay range from 81 to 90%, 4.0 to 6.0% and 6.6 to 14.8% respectively. The medium land soils have sand, silt and clay which varies between from 74.4 to 87.4%, 4.6 to 6.2% and 8.6 to 18.2% respectively. The low land soils have sand, silt and clay which varies between from 66.0 to 83.0%, 5.0 to 10% and 12.0to 24.0% respectively The soils have average per cent of sand, silt and clay were of 84.4, 4.65 and 10.68% in upland, 81.5, 5.58 and 12.38% in medium land and 76.94, 6.04 and 17.02% in low land respectively (Map no.1). Therefore it is observed that the sand and silt percentage gradually decrease while in case of clay percentage gradually increases from upland surface soils towards low land surface soils, which could be due to washing away of clay particles from upland and medium land during rain fall and deposition in the low land due to colluviation process. Similar results also find by Nayak (2014) [9] and Mishra *et al*. (2014) [6].

Available nutrient status

Soil reaction

Soil pH of surface soil samples of upland, medium land and low land were found to range in between 4.02 to 5.52, 4.38 to 6.25 and 4.88 to 6.65 respectively. The average soil pH values of the soil in upland, medium land and low land were found to be 4.59, 5.55 and 5.62 respectively (Map no.2). Soil electrical conductivity were found to be less than 2 dSm^{-1} and therefore all the soils of the study area are safe for all types of crop production. Thus the pH was found to gradually increase from upland surface soil towards low land surface soils, which could be attributed to removal of basic cations from soil surface of upland and medium land during intensive rainfall and their subsequent deposition in the low land. Hence, the major crop production constraint in the study area were found to be soil acidity. Similar results were also found by Priyadarshini (2017) [11].

Organic carbon

Soil organic carbon of upland, medium land and low land were found to range in between 3.2 to 5.2 g/kg, 4.1 to 6.0 g/kg and 4.4 to 6.9 g/kg respectively (Map no. 3). In upland, medium land and low land average soil organic carbon were found to be 4.07, 5.22 and 5.66 g/kg respectively. Hence, from upland to low land soil organic carbon gradually increase, which could be due to crop residue incorporation in the low land. In case of low land the oxidation of organic matter is slower than upland due to higher water table. Similar results were also observed by Mishra (1981) [7].

Available N, P, K

The available nitrogen content of soils of KVK, Nayagarh found to be low to medium. Soil available nitrogen content of upland, medium land and low land were found to range in between 113 to 175 kg/ha, 137 to 225kg/ha and 150 to 264 kg/ha (Map no. 4) with the average value of 135.5, 167.2 and 200.7 kg/ha respectively. Soil available phosphorous vary in between 7 to 10 kg/ha, 8 to 14 kg/ha and 10 to 18 kg/ha (Map no. 5) with the mean value of 10.2, 10.4 and 15.3 kg/ha respectively. Whereas soil available potassium vary in between 85 to 268 kg/ha, 150 to 332 kg/ha and 266 to 366 kg/ha (Map no. 6) with the mean value of 195.6, 260.4 and 311.5 kg/ha respectively Thus it was observed that the surface soils of KVK, Nayagarh farm were low to medium in available N and P, Medium to high in available K content. Similarly observation were made on KVK soils by Nahak *et al* (2016) [8] while studying soils of KVK farm of Ranital and Deogarh in Odisha.

Available sulphur and boron

Soil available sulphur content of upland, medium land and low land were found to range in between 2.56 to 4.86 mg/kg, 3.22 to 5.26 mg/kg and 4.1 to 6.02 mg/kg (Map no.7) with the average value of 3.46, 4.21 and 5.29 mg/kg respectively. Hot water soluble boron vary in between 0.45 to 0.75 mg/kg, 0.55 to 0.90 mg/kg and 0.61 to 0.95 mg/kg (Map no. 8) with the mean value of 0.58, 0.73 and 0.75 mg/kg respectively.

Thus it was observed that the surface soils of KVK, Nayagarh farm were low in available S content and sufficient in mean available B content. Such observation were also made on KVK soils by Patra (2019) [13] and Pattanayak (2019) [12] while studying of Keonjhar and Angul in Odisha.

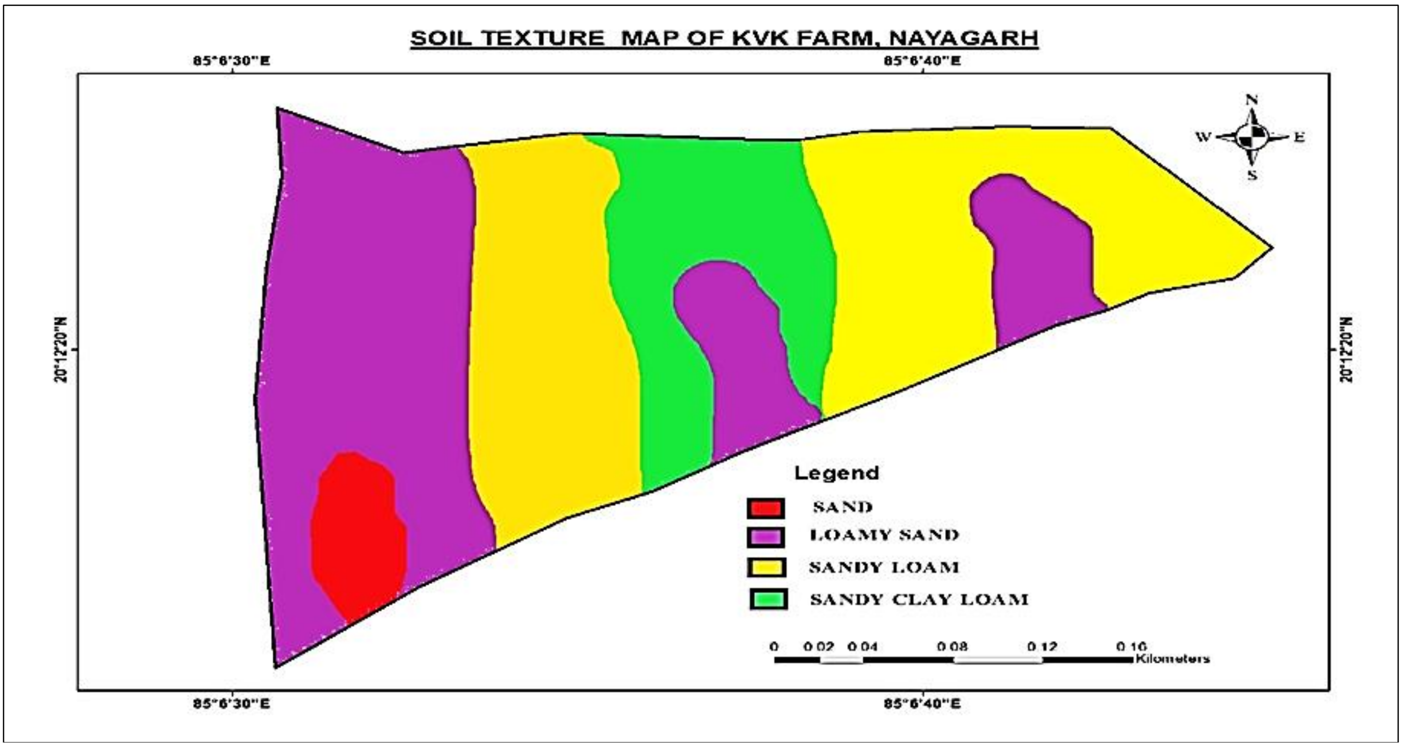
Table 1: Soil nutrients status of KVK farm Nayagarh

S.NO	Land type	Latitude	Longitude	Sand	Silt	Clay	Texture class	pH	EC(1:2)	Organic carbon	N	P	K	S	B
				(%)				(1:2)	(dSm^{-1})	(g kg^{-1})	Kg/ha			Mg/kg	
1	Upland	20^{0}12.284’	85^{0}06.588’	81.0	4.2	14.8	Loamy sand	5.52	0.11	5.2	175	12	268	4.86	0.75
2		20^{0}12.266’	85^{0}06.556’	81.6	6.0	12.4	Loamy sand	4.63	0.08	4.6	130	9	225	3.12	0.66
3		20^{0}12.239’	85^{0}06.514’	84.0	6.0	10.0	Loamy sand	4.52	0.02	4.2	150	11	185	3.29	0.69
4		20^{0}12.268’	85^{0}06.518’	90.0	4.4	6.6	Sand	4.14	0.06	3.2	113	7	85	2.56	0.45
5		20^{0}12.292’	85^{0}06.509’	84.8	4.0	11.2	Loamy sand	4.56	0.12	3.8	125	12	185	3.66	0.56
6		20^{0}12.268’	85^{0}06.549’	84.0	4.0	12.0	Loamy sand	4.77	0.09	4.2	137	11	234	3.32	0.52
7		20^{0}12.278’	85^{0}06.575’	88.0	4.4	7.6	Loamy sand	4.02	0.11	3.2	125	10	125	3.12	0.57
8		20^{0}12.272’	85^{0}06.533’	87.0	4.4	8.6	Loamy sand	4.26	0.04	3.6	125	9	150	3.12	0.55
9		20^{0}12.313’	85^{0}06.505’	84.6	4.2	11.2	Loamy sand	4.22	0.07	3.8	150	12	244	3.89	0.58
10		20^{0} 12.343’	85^{0}06.508’	83.0	4.6	12.4	Loamy sand	5.33	0.04	4.9	125	10	255	3.66	0.52
11	Medium land	20^{0}12.344’	85^{0}06.673’	84.0	6.8	9.2	Loamy sand	5.32	0.17	4.5	150	9	175	3.86	0.69
12		20^{0}12.354’	85^{0}06.668’	87.4	6.4	10.2	Loamy sand	5.46	0.12	5.1	150	10	185	3.42	0.63

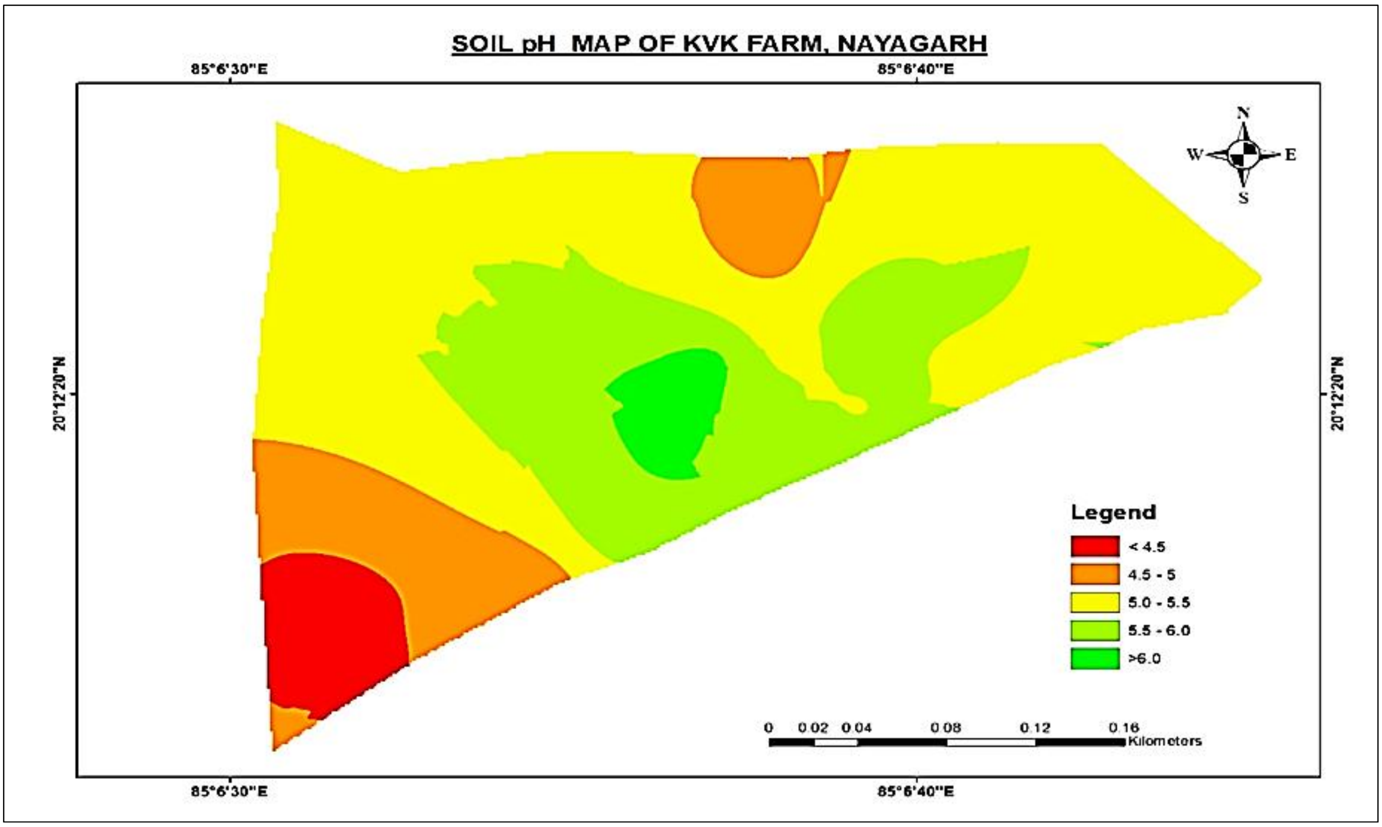
13		$20^0$12.360’	$85^0$06.660’	80.2	4.6	15.2	Sandy loam	6.12	0.09	5.4	175	9	288	3.02	0.68
14		$20^0$12.335’	$85^0$06.665’	84.0	6.0	10.0	Loamy sand	5.68	0.04	5.1	150	9	256	4.66	0.78
15		$20^0$12.342’	$85^0$06.663’	82.4	6.4	11.2	Loamy sand	5.36	0.11	5.4	185	11	305	4.12	0.82
16		$20^0$12.350’	$85^0$06.656’	79.0	4.8	16.2	Sandy loam	6.12	0.06	5.8	175	12	312	5.02	0.77
17		$20^0$12.340’	$85^0$06.655’	77.0	4.8	18.2	Sandy loam	6.25	0.04	6.0	225	14	332	5.26	0.90
18		$20^0$12.357’	$85^0$06.647’	79.6	6.2	14.2	Sandy loam	5.85	0.07	5.6	175	12	321	4.88	0.86
19		$20^0$12.363’	$85^0$06.641’	74.4	4.8	10.8	Sandy loam	5.02	0.16	5.2	150	10	280	4.67	0.66
20		$20^0$12.375’	$85^0$06.629’	87.0	4.4	8.6	Loamy sand	4.38	0.14	4.1	137	8	150	3.22	0.55
21		$20^0$12.330’	$85^0$06.652’	75.0	6.2	18.8	Sandy loam	5.02	0.04	6.6	250	26	321	5.76	0.75
22		$20^0$12.336’	$85^0$06.644’	72.4	5.2	22.4	Sandy clay loam	5.23	0.12	6.2	187	21	336	5.88	0.75
23		$20^0$12.340’	$85^0$06.640’	75.6	6.2	18.2	Sandy loam	5.56	0.63	5.6	185	18	321	5.28	0.86
24		$20^0$12.347’	$85^0$06.635’	83.0	5.0	12.0	Loamy sand	4.88	0.71	4.4	150	10	266	4.10	0.95
25		$20^0$12.354’	$85^0$06.629’	80.0	5.8	14.2	Loamy sand	5.29	0.23	5.1	175	10	288	4.21	0.66
26	Lowland	$20^0$12.324’	$85^0$06.644’	72.4	5.6	22.0	Sandy clay loam	5.89	0.26	5.8	225	14	355	5.86	0.74
27		$20^0$12.315’	$85^0$06.639’	80.0	5.0	15.0	Sandy loam	6.11	0.17	6.1	200	12	302	5.64	0.71
28		$20^0$12.326’	$85^0$06.632’	82.0	5.2	12.8	Loamy sand	5.55	0.64	4.6	150	9	246	4.95	0.75
29		$20^0$12.343’	$85^0$06.617’	66.0	10	24.0	Sandy clay loam	6.65	0.34	6.9	265	18	366	6.02	0.61
30		$20^0$12.297’	$85^0$06.590’	83.0	6.2	14.8	Loamy sand	6.05	0.22	5.3	220	15	314	5.22	0.72

Table 2: Comparative physical, chemical properties and fertility status of upland, medium land and low land surface soils of KVK farm Nayagarh

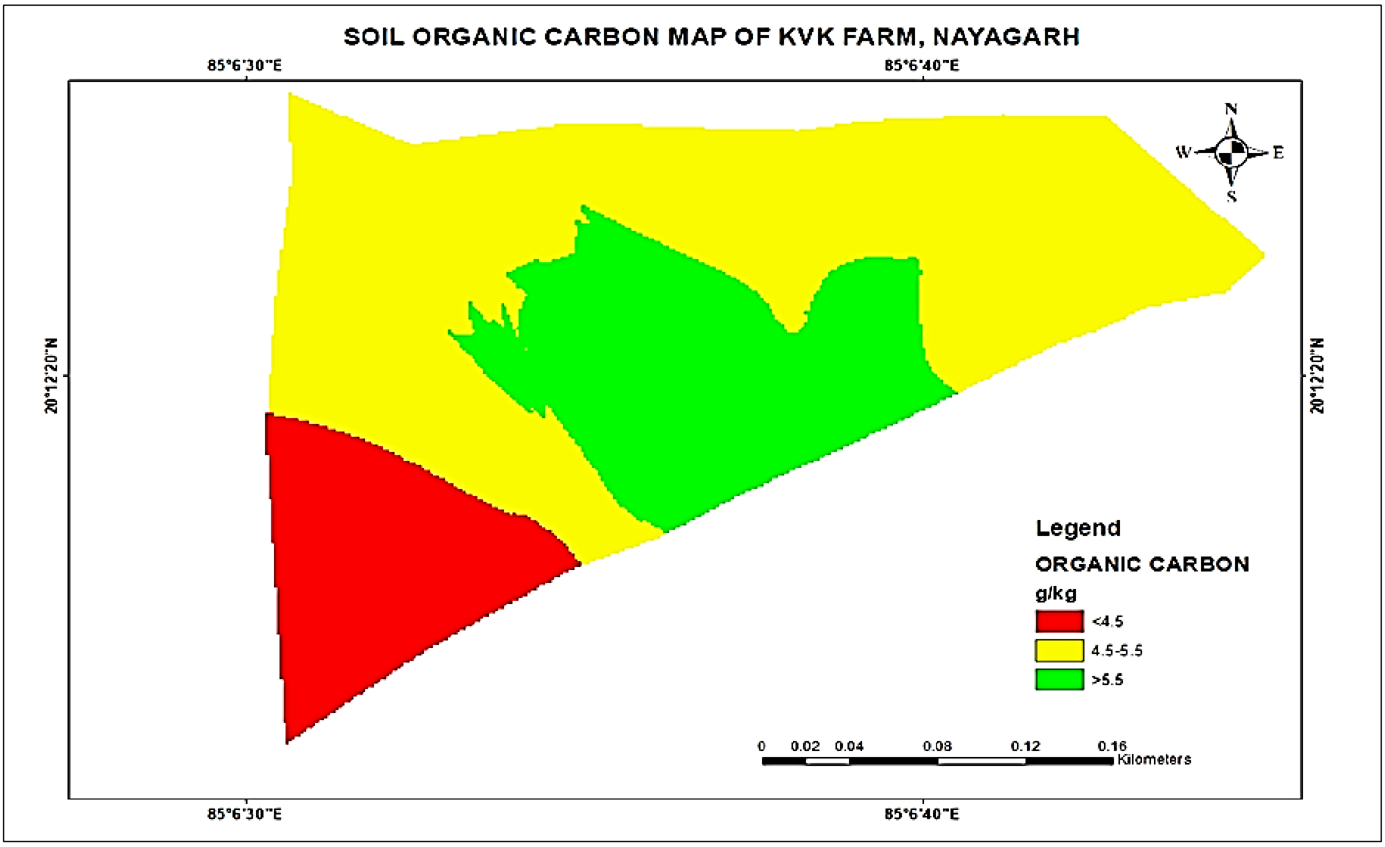
Parameters (Mean values)		Upland	Medium land	Low land
Percentage	Sand	84.4	81.5	76.94
	Silt	4.65	5.58	6.04
	Clay	10.68	12.38	17.02
pH(1:2)		4.59	5.55	5.62
Organic carbon (g/kg)		4.07	5.22	5.66
Avail. N (kg/ha)		135.5	167.2	200.7
Avail. P (kg/ha)		10.2	10.4	15.3
Avail. K (kg/ha)		195.6	260.4	311.5
Avail. S (mg/kg)		3.46	4.21	5.29
Avail. B (mg/kg)		0.58	0.73	0.75



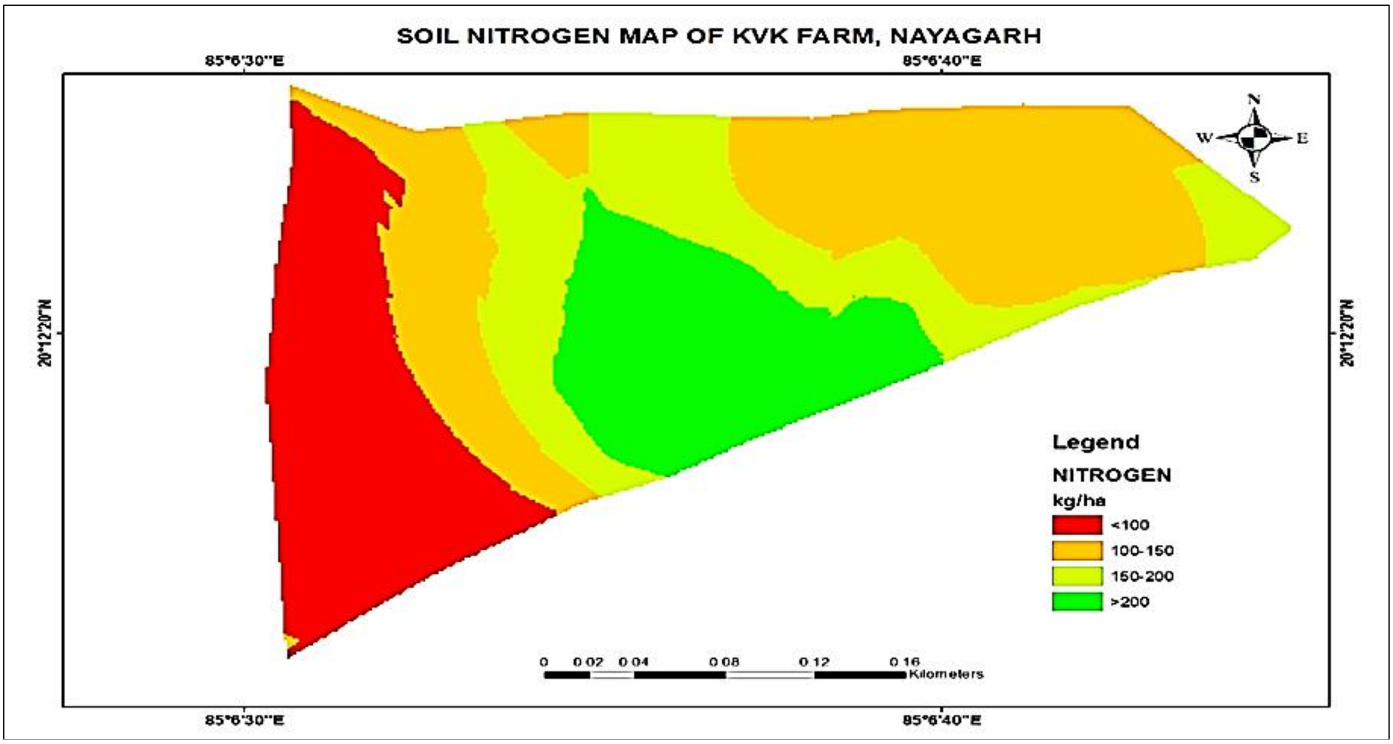
Map 1: Soil texture map of KVK farm, Nayagarh district



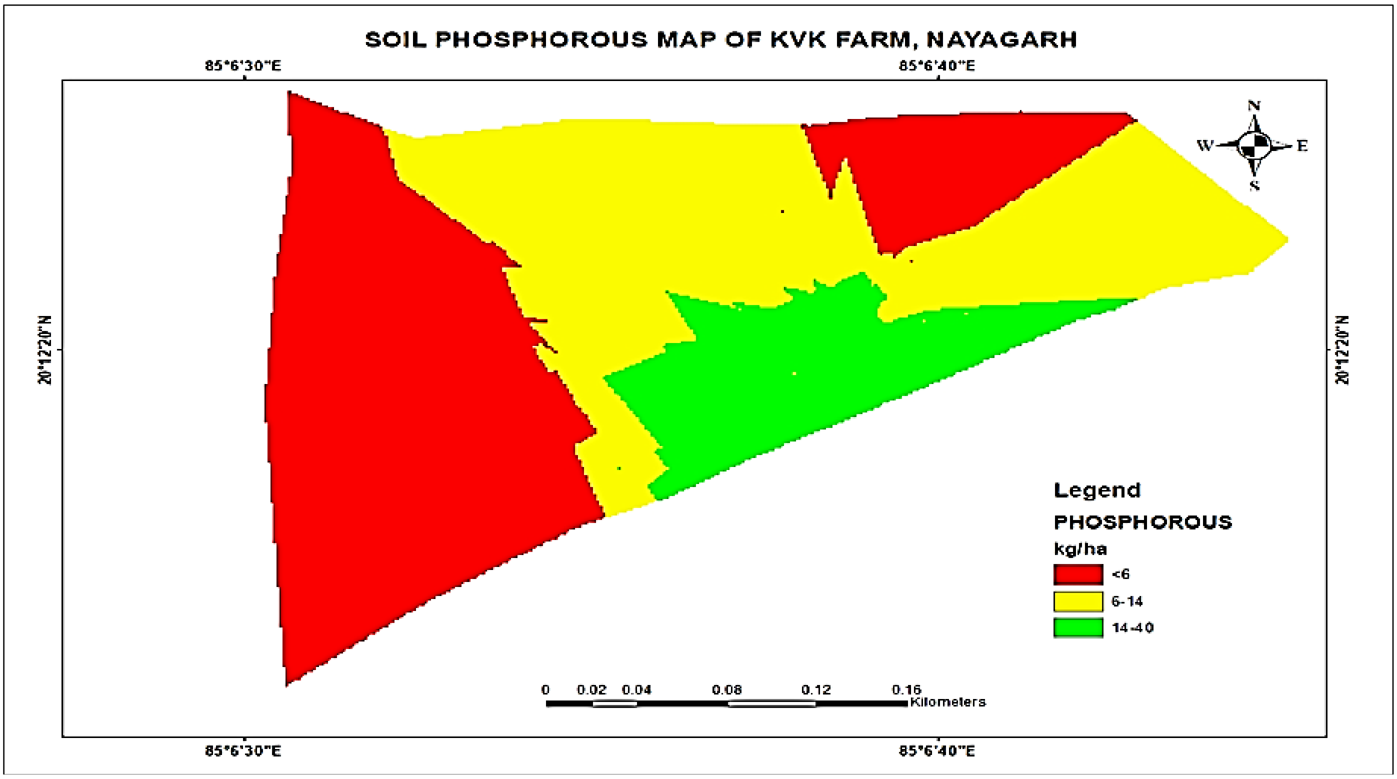
Map 2: GPS and GIS based soil pH map of KVK farm, Nayagarh district



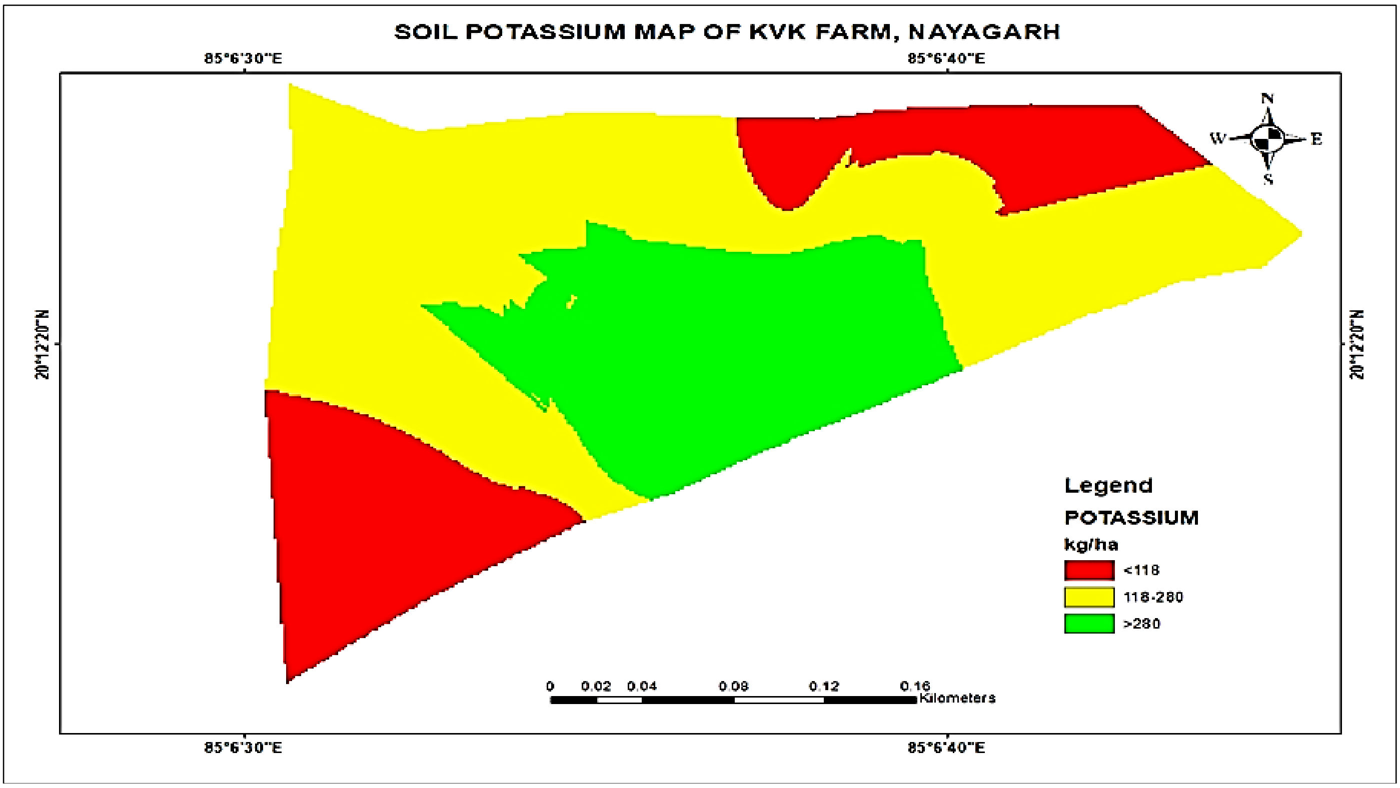
Map 3: GPS and GIS based soil organic carbon map of KVK farm, Nayagarh district



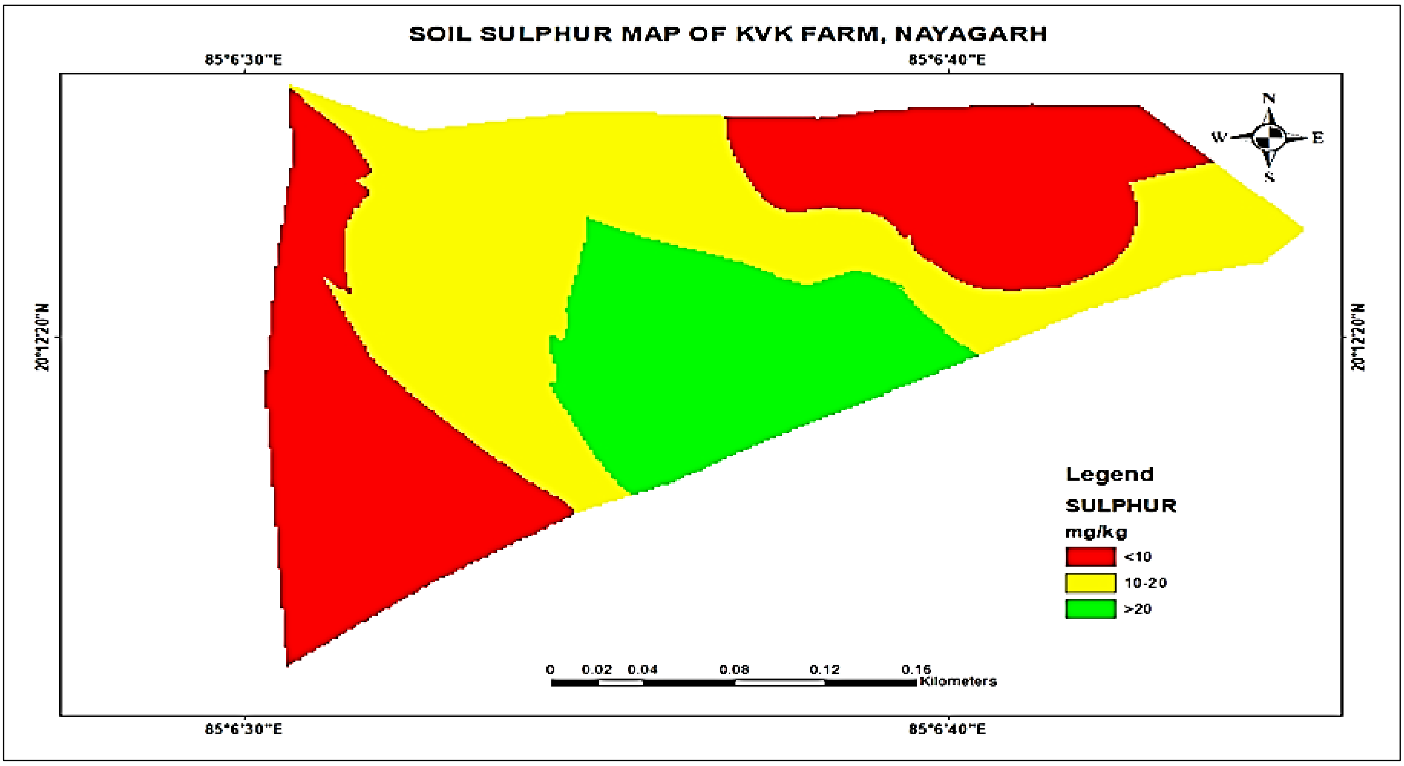
Map 4: GPS and GIS based soil available nitrogen map of KVK farm, Nayagarh district



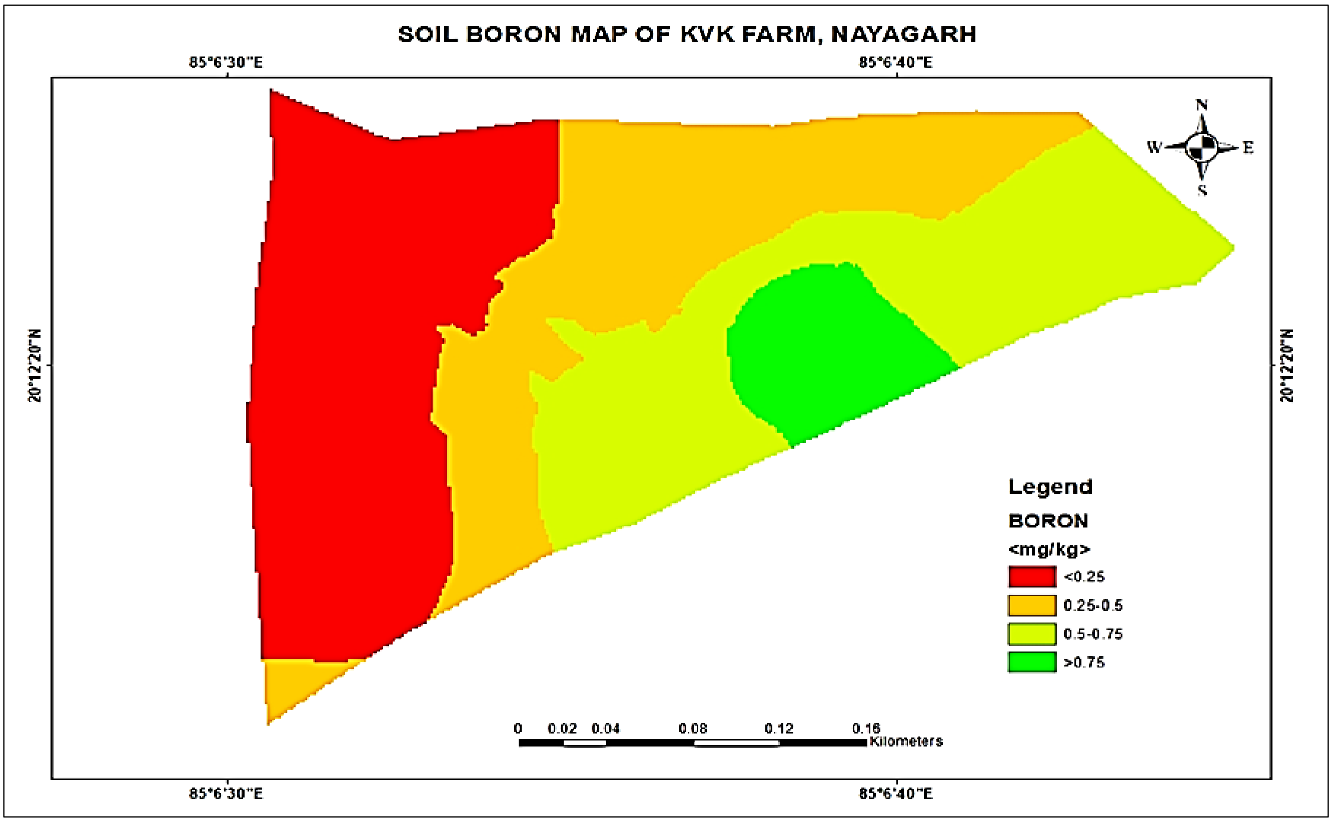
Map 5: GPS and GIS based soil available phosphorous map of KVK farm, Nayagarh district



Map 6: GPS and GIS based soil available potassium map of KVK farm, Nayagarh district



Map 7: GPS and GIS based soil available sulphur map of KVK farm, Nayagarh district



Map 8: GPS and GIS based soil available boron map of KVK farm, Nayagarh district

Conclusion

The major production constraint found in the study area is soil acidity. Application of @0.2LR liming material will help in reclamation of soil acidity and making availability of plant nutrients. When the available nutrient content in soil is low then added 25% more than the recommended doses of that particular nutrient good growth of crop. So 25% more nitrogen, phosphorous and sulphur added than the recommended doses

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