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Soil fertility assessment and mapping of rice super zone, Jhapa

SP Vista, SB Kumar, TB Ghimire, S Rai, B Kutu and BK Karna

SP Vista
Agriculture Research Station, Jumla, Nepal Agricultural Research Council, Nepal

SB Kumar
Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand, India

TB Ghimire
Seed Science and Technology Division, Khumaltar, Nepal Agricultural Research Council, Nepal

S Rai
Rajdevi Engineering Consultant Pvt. Ltd., Sankhamul, Kathmandu, Nepal

B Kutu
Rajdevi Engineering Consultant Pvt. Ltd., Sankhamul, Kathmandu, Nepal

BK Karna
Landuse Management Training Centre, Dhulikhel, Kavrepalan chowk, Nepal

Correspondence
SP Vista
Agriculture Research Station, Jumla, Nepal Agricultural Research Council, Nepal

Abstract
Rice productivity and its plantation area have been increasing in Nepal. This will certainly boost paddy production and bring down the import of rice. Ministry of Agricultural Development has estimated per hectare productivity of paddy in the country to increase to 3.5 tons in 2017-18 against 3.37 tons per hectare productivity recorded in the previous fiscal. However, paddy productivity in Nepal is comparatively low. In order to remain food secured and for enhancing production and productivity of food crops, the Government of Nepal has created pockets, blocks, zone and super zone for particular crop depending on the suitability of the crop according to agro ecological zones. This research aims to assess and prepare soil nutrient map of Rice super zone, Jhapa in Nepal. The specific objectives of the research were to assess soil texture, pH and organic matter status and simultaneously prepare soil fertility map of the rice super zone. A total of 202 soil samples were collected and nutrients were analysed using standard procedure in the soil laboratory. Composite soil samples were collected from 6 to 10 different spots of the area at 0-20 cm depth by using soil auger. The GPS location of each soil sampling point was noted. The soil sampling point of the super zone was determined by studying various aspects (area, slope, colour, texture, etc.) of the area. Based on the laboratory analysis, nutrient maps were prepared. Soil fertility maps were prepared by observing the critical nutrients required for the rice. Results revealed that soil reaction of Rice super zone was mostly found to be medium acidic (mean pH 5.52) which is almost very suitable for rice. Almost all soils of super zone were within the strongly acidic to slightly alkaline pH range that is very suitable for rice. The soil pH ranged from 4.6 to 7.89, but most of the samples showed moderately acidic range and rice can adapt wide range of soil pH. The organic matter content of the soil ranged from 0.4% to 4.06%, ranging from very low to high. Mean organic matter content of the sampled soil is 1.91% which falls under the category of medium. Most of the soils of rice super zone are under the category of medium organic matter content. Total nitrogen in the soils of area falls within the range of 0.02 to 0.2% that are under the category of very low to high. Mean N content is 0.09% that falls under the category of medium. Available phosphorus of the soils, in general falls within the range of 2 to 43 kg per hectare in the category of very low to medium. Mean Phosphorus content of the soil is 10.75 kg per hectare that fall in very low range. This nutrient is critical in rice super zone for rice production. The amount of available potassium in the soils of rice super zone ranges from 107 to 522 kg per hectare falling under the category of low to very high. The mean value of the available potassium in the soil is 224 kg per hectare that falls under the category of medium. Majority of the soils of study area is loam. There is also sandy loam, silty loam and silty clay loam types of soil in the area. Based on the soil analysis report, it could be concluded that the soils of rice super zone is critically low in phosphorus content. Immediate attention should be given to apply phosphatic fertilizer; otherwise this could limit crop production. The soil reaction is fair enough for cultivating rice crop at the moment. Nitrogen, potassium and Organic matter are also in medium range therefore, in order to obtain high production and productivity of rice, organic matter should be added in adequate quantity with sufficient N, P and K fertilizers. Soil fertility maps were prepared by setting criteria based on nutrient status that were tested in the laboratory and on the basis of nutrients that are critical for rice. Rice super zone soil was found having low (89.52%) and medium fertility status (10.04%).

Keywords: Soil fertility map, rice super zone, soil nutrients, etc.

Introduction
Paddy productivity and its plantation area have been increasing in Nepal. This will certainly boost paddy production and bring down the import of rice. Ministry of Agricultural Development has estimated

per hectare productivity of paddy in the country to increase to 3.5 tons in 2017-18 against 3.37 tons per hectare productivity recorded in the previous fiscal. However, paddy productivity in Nepal is comparatively low. Domestic rice should be made more competitive in terms of price and packaging to bring down rice import (Himalayan Times, 23 November, 2018). In this regard, Government of Nepal has created pockets, blocks, zone and Super zone for particular crop. Rice Super zone was initiated in Jhapa district of Nepal through Prime Minister Agriculture Modernization Project.

Soil Fertility management is one of the important task for food security and livelihood improvement of the local farmers. Soil is the sources for plant Nutrients supply and habitat for plants growth and development. Soil properties such as physical, chemical, and biological properties affect the plant growth and development. Different Crops requires different types of soil properties and nutrients for their optimum yield. Therefore, it is very much important to know the exact situation of soils and map them for further use in rice super zone. Farmers are growing crops without considering exact situation of soils. Sometimes, excess fertilizer is used without considering the inherent supplying capacity of the soil thus polluting the water body and environment. Synergism and antagonistic effect of each nutrient could also be forecasted depending upon the inherent soil nutrient status. Therefore, due to ignorance of such types of problems, soils are deteriorating every year resulting poor performance of crops.

Soil fertility studies and mapping is an effective way to diagnose soil status and recommend as per the need of the nutrient to particular crop in the area. Mapping can help decision makers and farmers to effectively manage soil acidity, fertilizer management, organic matter management and also physical and biological maintenance of the soil. Thus, studying and mapping of nutrient status is essential to judge the nutrient requirement and application of nutrients for the sustainable management of crop and soil health. Therefore, this study was carried out to prepare soil nutrient map of rice super zone, Jhapa in Nepal. The specific objectives of the research were to assess soil texture, pH and organic matter status and simultaneously prepare soil fertility map of the rice super zone.

Materials and Methods

Soil sampling point determination

Identification of representative soil sampling points to collect soil samples is important for preparation efficient map of the study area. The soil sampling point of the rice super zone was determined by studying various aspects (area, slope, colour, texture, etc.) of the study area. Location map and soil sampling points of the super zone is shown in the Figure 1-2 below.

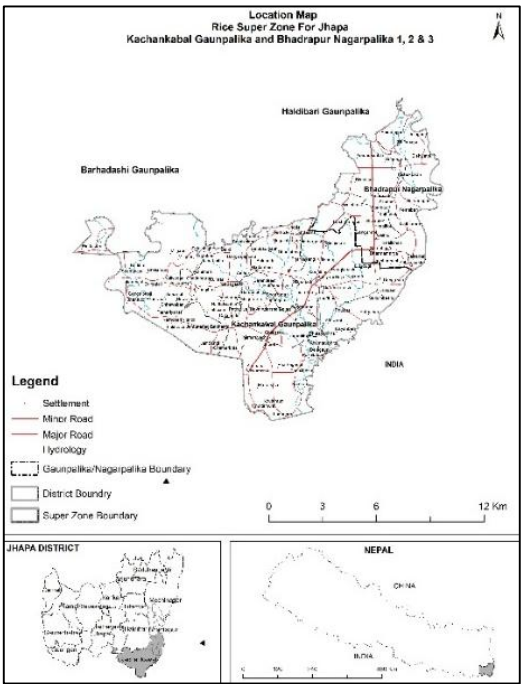

Fig 1: Location map of rice super zone, Jhapa

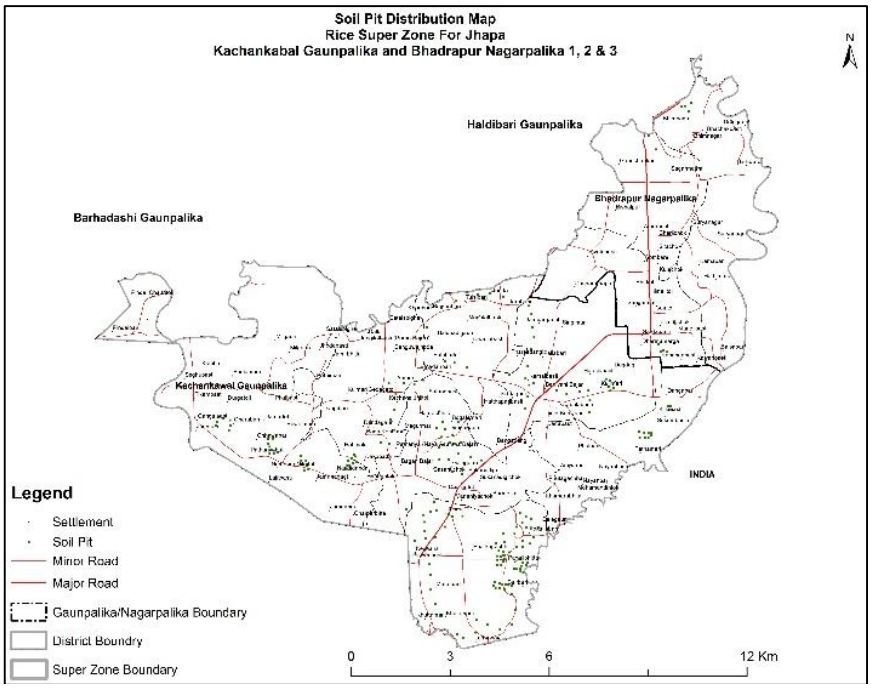

Fig 2: Soil sampling point of rice super zone, Jhapa

Rice super zone covers one Gaunpalika and one Nagarpalika but all the wards were not covered for Nagarpalika. The super zone of rice area covers Kachankawal Gaunpalika and Bhadrapur Nagarpalika but only ward no. 1, 2 and 3 were covered for Bhadrapur Nagarpalika (Figure. 1 and Table-2).

Collection and analysis of soil samples

Composite soil samples were collected from 6 to 9 different spots at 0-20 cm depth from the study area by using soil auger. A total of 202 soil samples were collected (Figure 2) and different physical and chemical properties of soils were analyzed after bringing soil samples to the laboratory using standard procedure (Table 1).

Table 1: Methods adopted for Soil analysis in the laboratory

S. N.	Parameters	Methods
1	Physical	
1.1	Soil Texture	Hydrometer (Bouyoucos, 1927)
2	Chemical	
2.1	Soil pH	Potentiometric 1:2 (Jackson, 1973)
2.2	Soil organic matter (SOM)	Walkely and Black (Walkely and Black, 1934)
2.3	Macro-nutrients	
2.3.1	Total Nitrogen	Kjeldahl (Bremner and Mulvaney, 1982)
2.3.2	Available P_2O_5	Modified Olsen's (Olsen *et al*., 1954)
2.3.3	Extractable K_2O	Ammonium acetate (Jackson, 1967)

Preparation soil fertility maps

Latitude (Lat) and Longitude (Long) were recorded by GPS from soil sampling points. Latitude, longitude and laboratory data were entered into excel and linked to ArcGIS 10.4.1 software for making soil fertility maps of rice super zone. The interpolation method employed was ordinary kriging. Based on the data obtained from laboratory soil analysis, all nutrient maps were prepared. Soil fertility maps were prepared by setting criteria based on nutrient status (as described by Khadka, 2069) [7] that were tested in the laboratory and on the basis of nutrients that are critical for rice. For rice, 3 score was given for N, 2 for K and 1 for P and based on this scoring the fertility map was prepared for rice super zone

Statistical Analysis

Summary statistics of the data obtained was computed using R software and presented for each parameter studied.

Results and Discussion

General analysis of the soil of Rice Super zone, Jhapa

Rice being a semi-aquatic crop, grows best under submerged condition. It can tolerate a wide range of soil reaction, but has preference to acid soil. It grows well in soils having a pH range of 5.5 to 6.5. The total area of the rice Superzone, Jhapa is 14753.51 ha and the total area of Jhapa district is 160950.49 ha. Area covered by Rice superzone is given in the Table-2 below.

Table 2: Area covered by Rice Superzone in hectare and percentage

S.N	Ward. No.	Gaunpalika/Nagarpalika	Area in haectare	Percentage
1	1	Kachankawal Gaunpalika	3072.94	20.83
2	3	Bhadrapur Nagarpalika	1646.18	11.16
3	4	Kachankawal Gaunpalika	1595.51	10.81
4	6	Kachankawal Gaunpalika	1522.24	10.32
5	3	Kachankawal Gaunpalika	1354.29	9.18
6	2	Kachankawal Gaunpalika	1191.17	8.07
7	5	Kachankawal Gaunpalika	1139.03	7.72
8	7	Kachankawal Gaunpalika	1089.45	7.38
9	1	Bhadrapur Nagarpalika	1086.62	7.37
10	2	Bhadrapur Nagarpalika	1056.08	7.16
Total			14753.51	100.00

Status of Soil Reaction

The soil reaction of Rice superzone was mostly found to be medium acidic. Mean soil reaction of the area is 5.52 (Table-3) that fall under the category of moderately acidic, which is almost very suitable for rice. Almost all soils of superzone were within the strongly acidic to slightly alkaline pH range that is very suitable for most of the rice. The soil pH ranged from 4.6 to 7.89, but most of the samples showed moderately acidic range where almost all major and micronutrients will be in available form except phosphorus. Rice and most food crops can be grown in such type of soil. Only few samples showed strongly acidic reaction. Since rice tolerates to wide range of soil pH, it can be cultivated without any amelioration but with respect to nutrient availability the role of pH is tremendous.

Table 3: Descriptive Statistics of the Rice Superzone, Jhapa on different soil variables

Variable	Mean	SE Mean	St Dev	COV	Min	Max	Range
pH	5.52	0.0273	0.387	7.02	4.630	7.89	3.26
Organic Matter (%)	1.91	0.0342	0.486	25.53	0.40	4.06	3.66
Total Nitrogen (%)	0.094	0.00168	0.0238	25.11	0.02	0.20	0.18
Available Potassium (Kg/ha)	224.38	4.78	67.99	30.30	107.2	522.6	415.4
Available Phosphorus (Kg/ha)	10.75	0.405	5.755	53.53	2.06	43.26	41.20
Clay%	15.99	0.420	5.965	37.31	7.0	43.6	36.6
% Sand	38.047	0.884	12.567	33.03	14.40	75.8	61.4
% Silt	45.96	0.832	11.823	25.72	6.0	76.0	70.0

Status of Soil Organic Matter content

The organic carbon or organic matter content of the soil ranged from 0.4% to 4.06%, ranging from very low to high. Mean organic matter content of the sampled soil is 1.91% which falls under the category of medium. Most of the soils of rice superzone are under the category of medium organic matter content. Organic matter is the heart of the soil and it plays vital role in crop performance and maintaining soil health. Arresting the fall of soil organic matter in the area will be one of the key to maintain better soil status.

Status of Total Nitrogen in soil

Total nitrogen in the soils of area falls within the range of 0.02 to 0.2% that are under the category of very low to high. Mean N content is 0.09% that falls under the category of medium. Presence of Organic matter in the soil is closely related with the amount of total N in the soil. Both parameters in the soils are within medium category. Care should be taken to grow rice with ample incorporation of organic manure in the area with low organic matter content and nitrogen.

Status of Available Phosphorus in soil

Available phosphorus of the soils, in general falls within narrow range. It falls within the range of 2 to 43 kg per hectare in the category of very low to medium. Mean Phosphorus content of the soil is 10.75 kg per hectare that fall in very low range. The soil of Jhapa rice superzone is found having very low amount of phosphorus in the soil. Immediate attention should be given to apply phosphatic fertilizer, otherwise this could limit crop production.

Status of Available Potassium in soil

The amount of available potassium in the soils of rice superzone ranges from 107 to 522 kg per hectare falling under the category of low to very high. The mean value of the available potassium in the soil is 224 kg per hectare that falls under the category of medium. Appreciable concentration of available potassium were found in the soil of rice superzone. Therefore, Potassium should be added in the soil in full amount in the area.

Status of Soil texture

Majority of the soils of study area is loam. There are also sandy loam, silty loam and silty clay loam types of soil in the area.

Soil Fertility Status of Rice superzone

Based on the laboratory analysis of the soil, fertility of soils were categorized as very low, low, medium, high and very high. Area of super zone was estimated that fall in each category and coverage of the category was calculated in percentage for rice superzone that is presented in the table-4 below.

Table 4: Soil fertility statistics of Rice super zone, Jhapa

SN	Fertility Rating	Area (Ha)	Percentage
1	High	64.96	0.44
2	Low	13158.18	89.52
3	Medium	1475.64	10.04
	Grand Total	14698.78	100.00

Soil fertility maps were prepared by setting criteria based on nutrient status that were tested in the laboratory and on the basis of nutrients that are critical for the super zone. 90% of the total area of rice super zone has low soil fertility whereas rest 10% area has medium soil fertility. Management of nutrients is necessary for rice super zone for higher production and productivity. Fertility is critical in rice superzone. Based on the soil analysis report, it could be concluded that the soils of rice superzone is critically low in phosphorus content but is fair enough for cultivating rice crop at the moment.

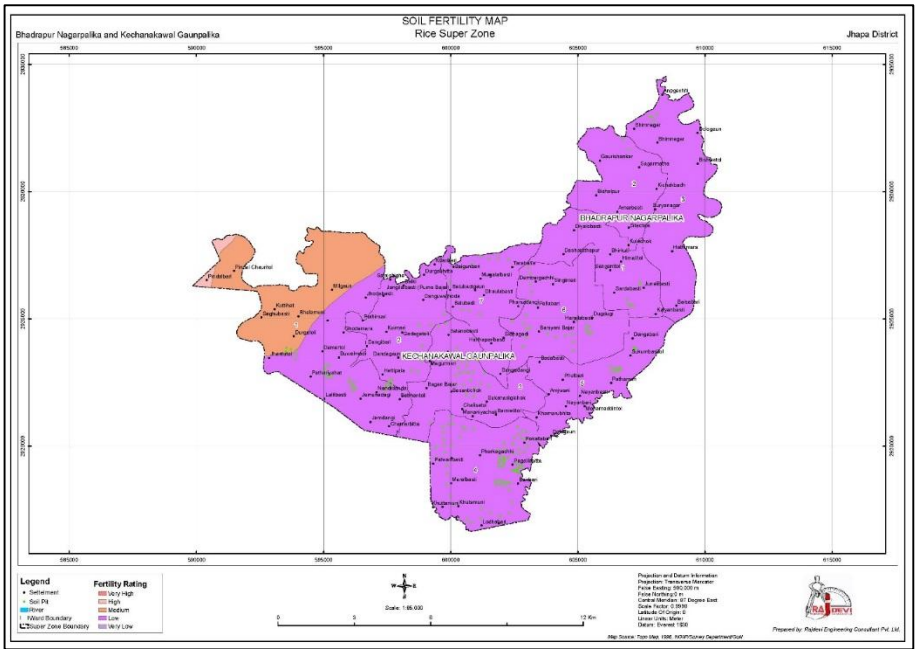

Fig 3: Soil fertility map of rice super zone, Jhapa, Nepal

Summary and Conclusion

Soil of rice superzonewas mostly found to be medium acidic in reaction with very low to high organic matter content. However, mean organic matter content showed the category of medium. Total nitrogen in the soils of area falls within the range of 0.02 to 0.2% that are under the category of very low to high. Mean N content is 0.09% that falls under the category of medium. Available phosphorus of the soils, in general falls within narrow range. It falls within the range of 2 to 43 kg per hectare in the category of very low to medium. Mean Phosphorus content of the soil is 10.75 kg per hectare that fall in very low range. The amount of available potassium in the soils of rice superzone ranges from 107 to 522 kg per hectare falling under the category of low to very high. The mean value of the available potassium in the soil is 224 kg per hectare that falls under the category of medium. Majority of the soils of study area is loam. There is also sandy loam, silty loam and silty clay loam types of soil in the area.

Based on the soil analysis report, it could be concluded that the soils of rice superzoneis critically low in phosphorus content. The soil of Jhapa rice superzone is found having very low amount of phosphorus in the soil. Immediate attention should be given to apply phosphatic fertilizer; otherwise this could limit crop production. The soil reaction is fair enough for cultivating rice crop at the moment. Nitrogen, potassium and Organic matter are also in medium range therefore, in order to obtain high production and productivity of rice, organic matter should be added in adequate quantity with sufficient N, P and K fertilizers.

For sustained production of the rice crops in the area soil quality improvement through green manure production and incorporation in the rice field could be the best and cheapest solution to increase organic matter and nitrogen supply for plant. Additionally, incorporation of organic matter and crop residue, introducing legume crops as an intercropping or cover crops, etc. could be recommended.

Acknowledgement

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Annexe 1: Nutrient Status Maps of Rice Super Zone, Jhapa

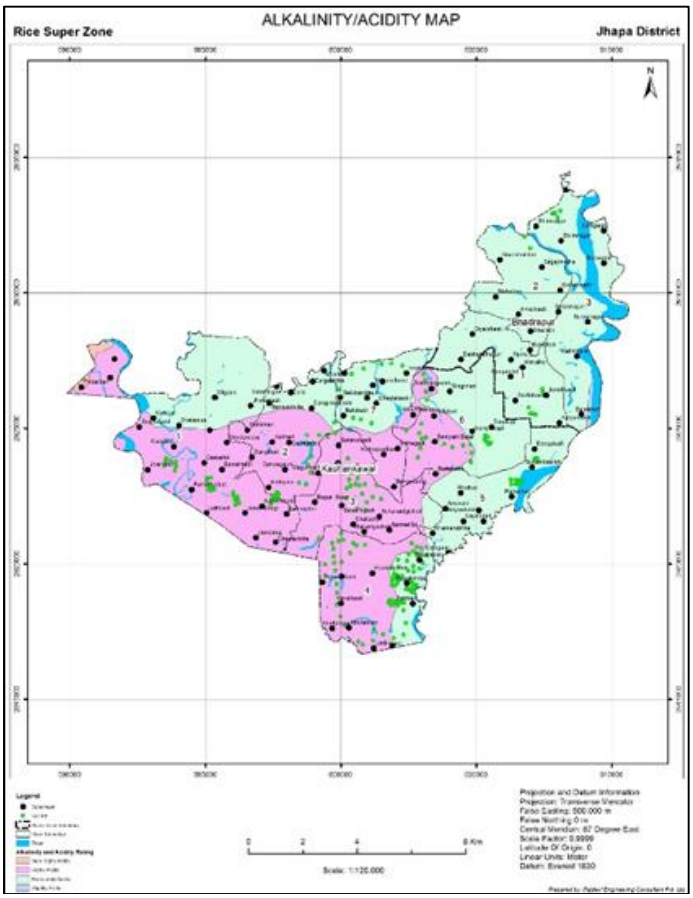

Fig 4: Soil reaction map of rice superzone, Jhapa

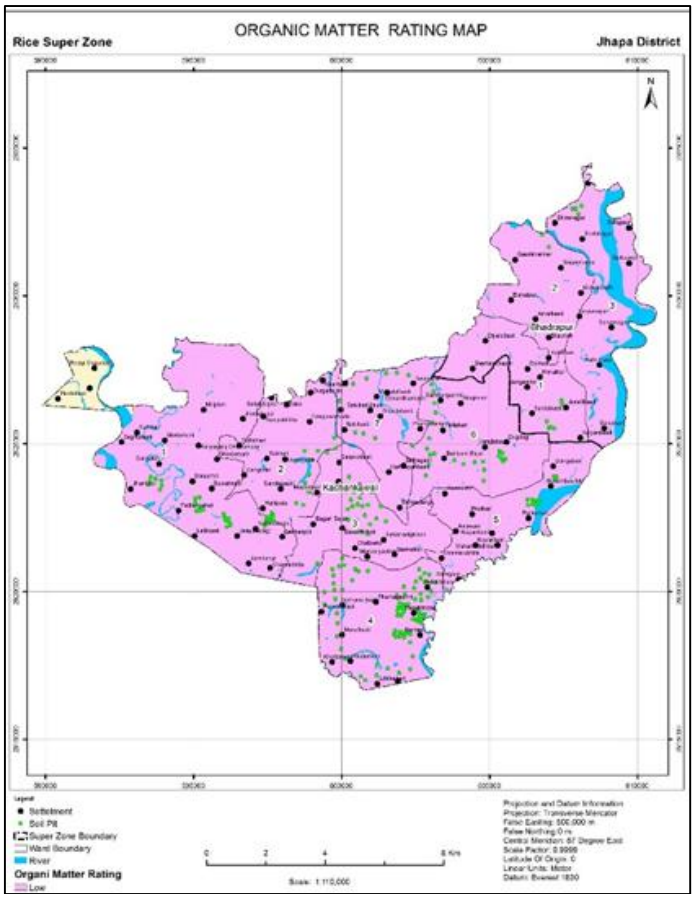

Fig 5: Organic Matter content map of rice superzone, Jhapa

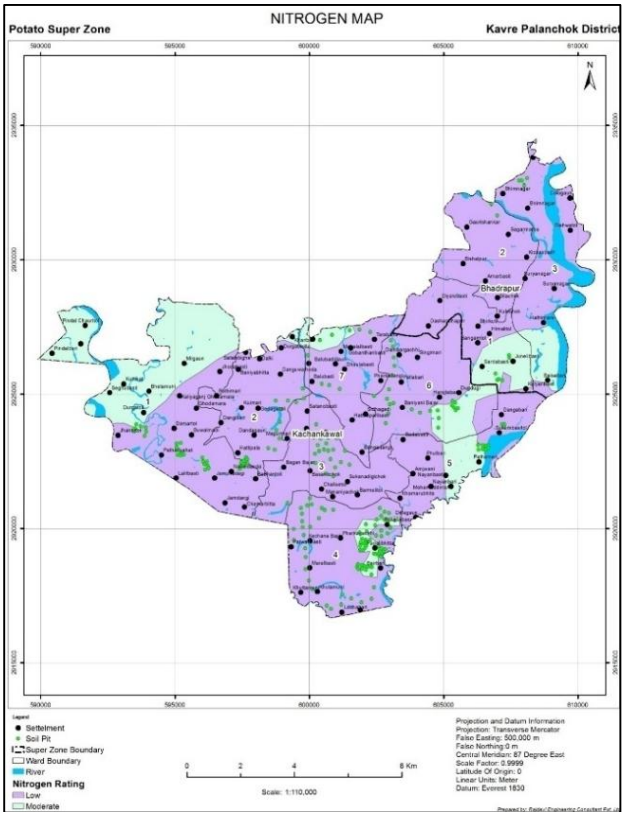

Fig 6; Nitrogen status map of rice superzone, Jhapa

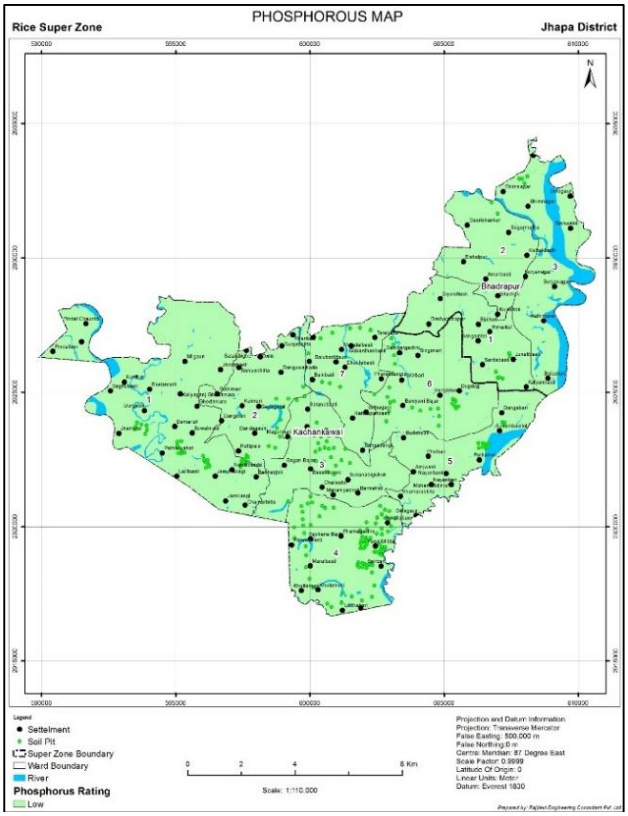

Fig 7: Available Phosphorus status map of rice superzone

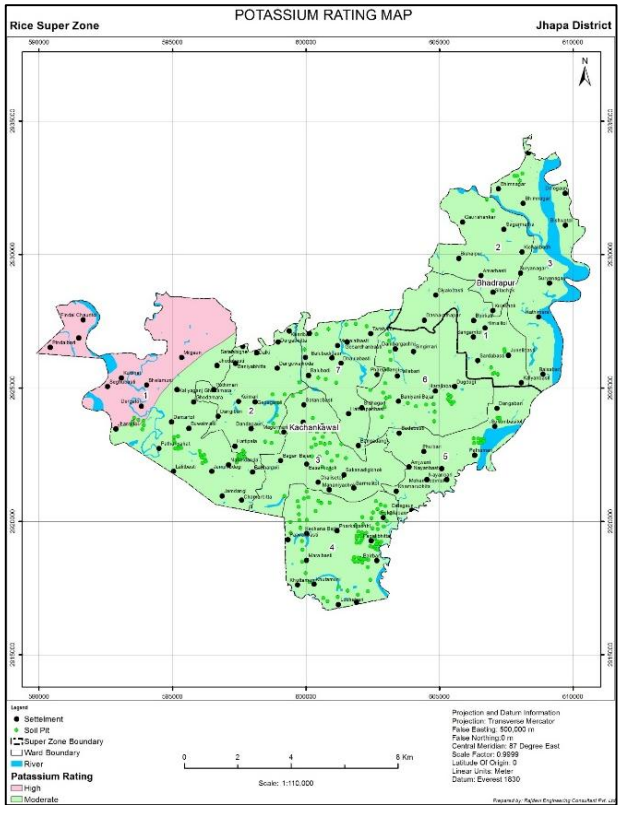

Fig 8: Available Potassium status map of rice superzone

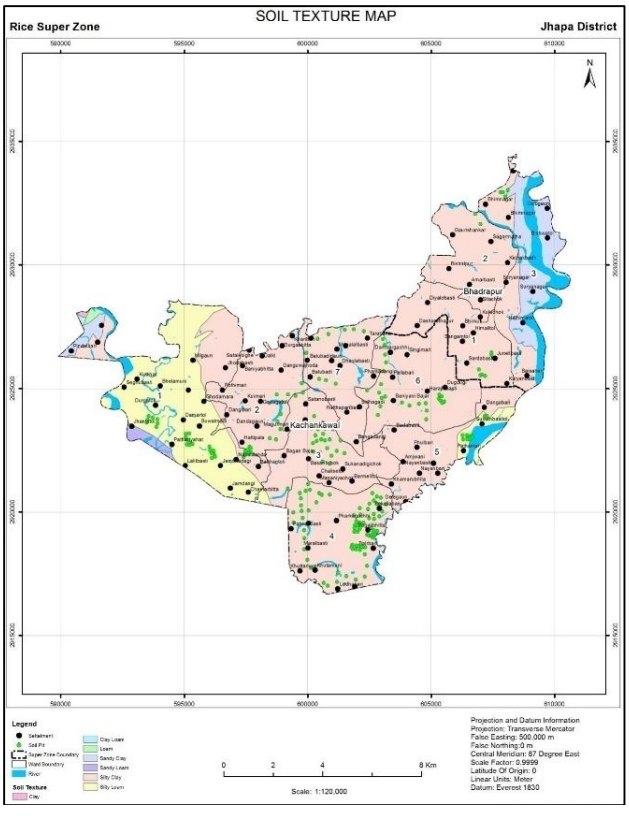

Fig 9: Soil textural map of rice Superzone, Jhapa