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ASSESSMENT OF SOIL POTENTIALITY FOR CROP CULTIVATION IN DAMARI VILLAGE, KATSINA STATE, NIGERIA

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Abstract

The study examines the physical and chemical properties and assessed soils using fertility assessment for rice cultivation in Damari village, Katsina State. Point-composite soil sampling methods was used for the collection of soil samples between the depths of 0-20cm. The soil samples were collected from sampled plots under rice cultivation and tested for some physical and chemical properties. The soil fertility requirements for rice were used to assess the soil potentiality for rice cultivation. The result reveals that the soil properties including average pH of 5.12, Oc of 0.18%, P of 27.05ppm and K of 0.024cmol/kg are below average compared to rice requirements. Some of the soil properties were found to be at very low fertility level. These include OC, N, K, Ca, Mg and CEC. The values of soil micronutrients including Mn of 4.98 g/kg and Zn of 11.28 g/kg are above the rice requirements and other crop cultivation that led to toxicity. Analysis of variation (ANOVA) show that calculated value F (2.56) is less than Table value (12.69), to suggest that there is no variation among the areas. Therefore, it can be concluded that the soil potentiality for crop cultivation is at low level. The use of chemical as pesticide should be discouraged; integration of organic manure from animal and inorganic fertilizers should be maintained to increase crop production to meet the people's demand for sustainable development.

Key Word: Assessment, Crop, Cultivation, Potentiality, Soil, Katsina

1. Introduction

The vast majority of farmers who experience it on their farms acknowledges declining soil fertility as a problem. It is, at the same time, a problem for society as a whole as it is related to issues of agricultural sustainability, soil biodiversity, carbon sequestration and watershed functions (Izac, 2003). A number of large existential environmental challenges have been recognized for the sustainable development of humanity and planet earth (McBratney, 2013). These are food security, water security, energy security, climate change abatement, biodiversity protection and ecosystem service delivery (Bouma and McBratney, 2013).

Rice (*Oryzasativa*) is one of the most important stable food crops in the world. In Asia, more than two billion people are getting 60-70 percent of their energy requirement from rice and its derived products (Source?). In India, rice occupies an area of 44 million hectares with an average production of 90 million tons with productivity of 2.0 tons per hectare (Geethalakshmi, Ramash, Palamuthiksoli and Lakmashmar, 2011). Rice is a cereal belonging to the Gramineae, a large monocotyledonous family of some 600 genera and around 10,000 species (Ajala and Gana, 2015). It is valued as the most important staple food for over half of the world population and ranks third after wheat and maize in production on world basis. More than half of the world's population depends on rice as the major source of calories.

Rice is unarguably one of the most popular food in Nigeria. It is a staple food. In fact, almost everybody in different forms (Mba, 2016) consumes it. Additionally, Daudu *et al* (2014) pointed out that rice is a predominant staple food in Nigeria, providing significant proportion of dietary energy supply, dietary protein and dietary fat. They further added that rice grain is reported to consist of 75-80% starch, 12% water and only 7% protein with a full complement of amino acids. Rice is

cultivated in virtually all the agro-ecological zones in Nigeria. Despite this, the total land area under rice cultivation is relatively small (Okoruwa, Ogundele and Oyewusi, 2006). Estimate of locally produced rice in Nigeria for the year, 2002 was 2.9 million tonnes (FAOSTAT, 2005). Also, only about 6.7% of the 25 million hectares of land cultivated for various food crops were cultivated for rice between 2000 and 2002 (Osiname, 2002).

Almost all the needs of man are derived from the soil (Essiet, 1997). It is thus, of paramount importance, this strategic resource be properly utilised to ensure sustained benefits and continued sustenance. According to Yusuf (2011), tropical soils are not generally infertile, but infertile soils are common in the tropics. The vast majority of farmers who experience it on their farms acknowledges declining soil fertility as a problem. Mortimore et al. (2010) reported that farmers try to obtain organic manure or purchase inorganic fertilizers for

application in micro-doses. Success in fertilization thus, depends on economic resources (livestock or cash). The absolute level of soil fertility declines with the rainfall northwards in Nigeria.

Damari village is been selected mainly due to its location in Sabuwa local government area and the southern part of Katsina State which has a peculiar agroecology, different from all parts of Katsina State (FAO, 2005). It is the most humid part with agroecology similar to that of southern Kaduna and Bauchi, Guinea savanna.

2. Materials and Method

According to Ahmed (2019), the study area is characterized by homogeneity in terms of topography, climate and microclimate,

parent materials, organism, geology as well as farm management. Therefore, sampling points in the area have uniform features taken into consideration.

2.1 Field Work

Fieldwork (survey) was carried out on the study area to identify farmlands that cultivate rice. It also involved physical characteristics of the study area. These include soil and land use types, soil management, vegetation etc.

Point-composite samples were drawn from quadrant of $12m^2$ in which five samples at the depth of 0 to 20cm were collected randomly within the quadrant and bulked as

one composite sample. In this regard, according to Yusuf (2017) five samples were collected within the 12 m^2 and bulked as composite representative of the area. The point-composite samples collected were air-dried, put in cotton yard bags, labelled appropriately using codes, and stored. They were taken to the soil laboratory of Bayero University Kano for further analyses of soil chemical properties. Geographic Positioning System (GPS) was used to locate the sampled location.

2.2 Laboratory Analysis

The samples were analysed for fertility indicators for the following; clay, soil pH, total nitrogen, exchangeable bases (Na^+, Ca^{++} and Mg^{++}), available phosphorus, potassium and nitrogen (Lamofor *et al.*, 1990; Ibitoye, 2008; Eno *et al.*, 2009; Estefan, Sommer and Ryan, 2013; Garba, 2014). Statistical analysis for coefficient of variation and analysis of variation (ANOVA) were used. The procedures for the analysis are stated in Table 2.1.

Table 2.1: Methods of Determining Physical and chemical Properties of Soil Samples

Physicochemical Parameters	Methods Adopted
PSD & AWHC (% & cm/cm)	1:25 water ratio Hydrometer & calculation.
Soil pH	pH meter (1:25 water ratio)
Total nitrogen (%)	Micro kjeldahl
Phosphorus (ppm)	Spectrophotometry (centrifuge) and calculation
Organic carbon (%)	Walkley black (dichromate solution), leaching, titration and calculation
Exchangeable bases (cmol/kg)	Bray 1 (NH_4OAC, Na^+ & K^+ by flame photometer and Ca^{++}& Mg^{++} by atomic absorption, AAS)
CEC (cmol/kg)	Calculated by the sum of exchangeable bases
Micronutrients Mn, Zn, Fe, Cu (g/kg)	Leaching, Titration, AAS and calculation

Source: Adapted from Eno *et al.* (2009)

3. Study Area

Damari village is located in Sabuwa local government area at the south end of Katsina State along Sabuwa to Dandume road, between latitude 11°06'N – 11°10'N and longitude 6°55'E – 7°20'E (Katsina State Ministry of Lands, Survey and Environment, 2013). The rainy season of Damari village is between the month of April to October and it has its peak in the month of August. The rainfall ranges from 7 to 8months and recorded 900mm – 1,200mm annually, based on average of 10years from 2000 to 2009. It is characterized by conventional rainfall (dry and wet climate) followed by long dry season of 4 – 5 months (Meteorological Unit, Umaru Musa Yar'adua International Airport Katsina, 2012). The mean maximum temperature of Damari village is 38°C in the month of April and May. At the peak of rainy season, average maximum temperature is 37°C and in December, average temperature is 19°C (Meteorological Unit, Umaru Musa Yar'adua International Airport Katsina, 2012).

The wind speed of Damari is 1.5 km/h in the month of July to September and as high as 3.2 km/h around December to January. The direction of wind is northeast to south-west and dry in December to January. Wind direction is south-west to northeast during rainy season, northeast to south-west during the dry season. Relative humidity denotes the amount of water vapour in the atmosphere (air) compared to what the air can hold when fully saturated. The minimum relative humidity of Damari is 19% in December to January and maximum as 98% around July to September, (Meteorological Unit, Umaru Musa Yar'adua International Airport Katsina, 2012).

Soils are the mixture of rock particles loosened by weathering, mineral salts and dead vegetation matter. In the southern part of Katsina State, the soils are largely clay in nature and are very fine in texture. The soils of Damari village are clay in nature (Chude, 2012). Below are Figures 3.1 and 3.2 showing map of the study area.

The most cultivated food crops are sorghum, maize, millet, white beans, vegetables and cocoa yam. The cash crops include rice, groundnut, sugar cane and others. The domesticated animals including goat, sheep and cow use to feed on the leaves and cane of the crops after harvest (Chude, 2012; Ahmed, 2014).

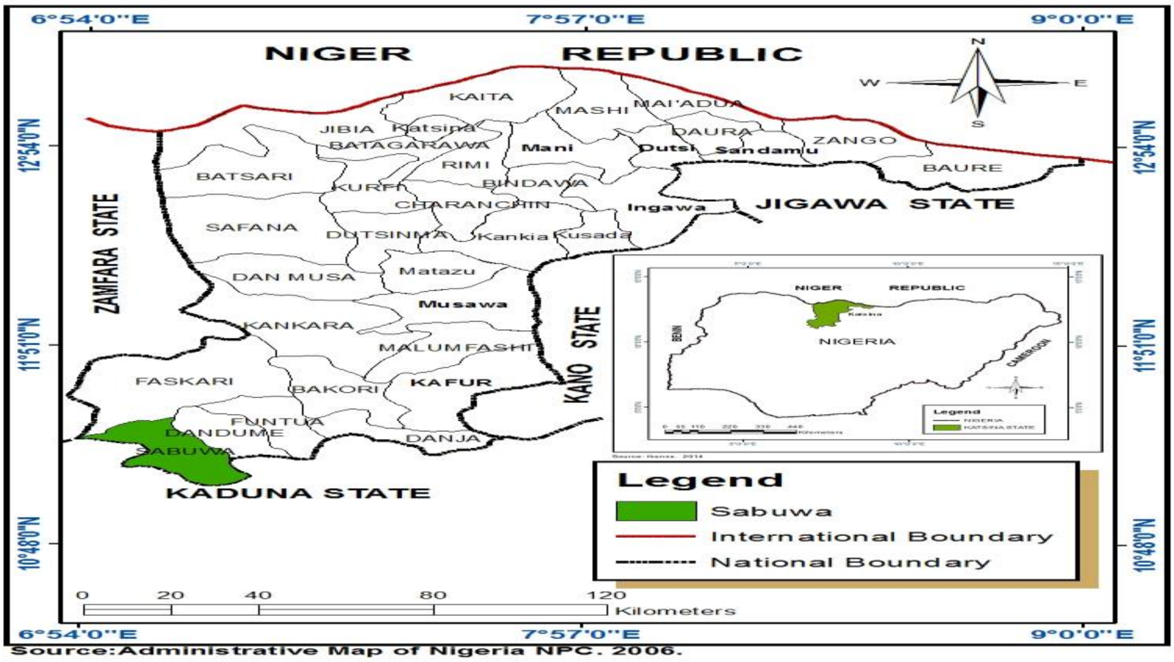

Figure 3.1: Katsina State showing Sabuwa Local Government Area

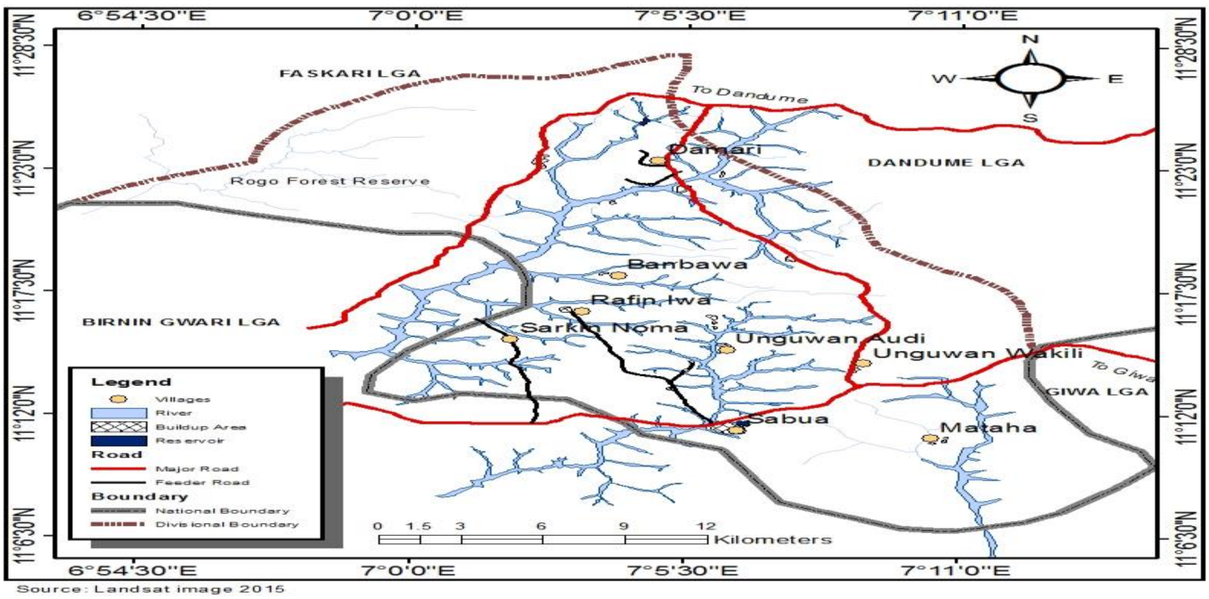

Figure 3.2: Sabuwa Local Government Area showing the Study Area, Villages and Drainage System

4. Results and Discussion

The result shows e soil physical and chemical properties of the area (Tables 4.1 and 4.2). Udoh and Ogunkunle (2009); Agbede (2009); Yusuf (2016) maintained that soil physical properties are properties that do not involve chemical or biological processes. He further suggested that the values of soil physical properties are usually indications of certain condition or potentialities of the soil.

Table 4.1: Soil Physical Properties in Damari Village

ID	Location	PSD (%)			Textural	AWHC
		Clay	Silt	Sand	Class	(cm/cm)
C15	11º10.557'N-007º08.007'E	22.64	48.00	29.36	Loam	0.16
C16	11º10.558'N-007º08.999'E	30.64	38.00	31.36	Clay Loam	0.15
C53	11º12.605'N-007º10.401'E	19.20	33.44	47.36	Loam	0.13
C54	11º12.541'N-007º10.485'E	31.20	21.44	47.36	Sandy Clay Loam	0.12
C55	11º12.524'N-007º10.485'E	31.20	27.44	41.36	Clay Loam	0.13
C56	11º12.527'N-007º10.434'E	27.20	35.44	37.36	Loam	0.14
C60	11º23.797'N-007º04.708'E	39.20	39.44	21.36	Clay Loam	0.14
C61	11º23.693'N-007º04.768'E	32.64	52.56	14.80	Silt Clay Loam	0.17
C62	11º23.202'N-007º04.687'E	21.20	33.44	45.36	Loam	0.13
C63	11º23.222'N-007º04.671'E	25.20	33.44	41.36	Loam	0.13
C64	11º23.212'N-007º04.636'E	25.20	33.44	41.36	Loam	0.13
C65	11º23.180'N-007º04.640'E	25.20	41.44	17.36	Loam	0.15
C66	11º23.149'N-007º04.601'E	55.20	33.44	11.36	Clay	0.12
C67	11º22.950'N-007º05.483'E	41.20	41.44	17.36	Silt Loam	0.14
C68	11º23.019'N-007º05.450'E	48.64	26.56	24.80	Clay	0.12
C69	11º23.071'N-007º05.412'E	35.20	31.44	33.36	Clay Loam	0.14
C70	11º22.893'N-007º05.579'E	51.20	33.44	15.36	Clay	0.12
C71	11º22.858'N-007º05.634'E	31.20	35.44	33.36	Clay Loam	0.14
C72	11º22.913'N-007º05.624'E	48.64	38.56	12.80	Silt Loam	0.13
C73	11º23.761'N-007º06.212'E	50.64	20.50	28.80	Clay	0.13
C74	11º23.791'N-007º06.203'E	50.64	20.56	28.80	Clay	0.12
Average		**35.39**	**34.24**	**30.37**		**0.14**
SD		**13.28**	**7.10**	**14.58**		**0.0001**
CV %		**37.52**	**23.36**	**48.01**		**0.10**

Source: Field Work and Laboratory Analysis (2018)

From Table 4.1, it shows the high clay of 51.20% and lowest clay of 19.20% at the centre and northern part of the area respectively, with a mean clay of 35.39% and co-efficient of variation of 37.52%. This shows that there was no variation among the soil samples. The highest AWHC of 0.17 cm/cm and lowest of 0.12 cm/cm were recorded respectively. The values were very low for crop cultivation compared to AWHC of 0.62 cm/cm and 3.12 cm/cm at Musawa area (Ahmed, 2014).

The implication in very low AWHC is that the soils may lead to dry overtime and decline in preserving and supply of nutrients. According to Yusuf (2016) available water holding capacity is the amount of water (moisture) the soil can hold for the use of plants roots for certain period of time. The values obtained in this study were within the range of moderate soil fertility class and are good for crop cultivation as pointed out by Essiet (1997); Chude, Jayeoba and Berding (2012) that soils with clay ranging from 20-30%, are within the moderate fertility class.

Maniyunda and Malgwi (2011) said that soils with clay less than 35% are classified as moderate fertility. Additionally, the values were moderate levels compared to requirements for rice. As suggested by Isitekhale, Aboh and Ekhomen (2014); Yusuf (2015) that the clay requirements for rice range from 33.0% to 50.0% and AWHC from 2.0 cm/cm to 4.0c m/cm respectively. Therefore, soil fertility in this regard can be classified at moderate level.

Table 4.2: Soil Chemical Properties in Damari Village

Sample ID	pH	OC %	N %	P ppm	Ex. Bases (Cmol/kg)				CEC Cmol/kg	Micro Nutrients (g/kg)			
					Na	K	Ca	Mg		Cu	Fe	Zn	Mn
C15	5.71	0.67	0.25	24.23	0.001	0.014	0.233	0.033	0.68	1.39	1.44	19.65	4.50
C16	6.03	0.29	0.21	22.90	0.004	0.017	0.833	0.033	1.74	1.28	1.11	9.35	5.25
C53	4.73	0.08	0.16	22.90	0.003	0.020	0.600	0.033	1.06	0.73	0.89	5.53	0.13
C54	5.13	0.12	0.19	25.76	0.004	0.009	0.342	0.050	0.80	0.19	0.67	4.82	0.88
C55	4.81	0.08	0.19	28.63	0.002	0.023	0.583	0.033	1.04	0.19	0.44	8.65	0.88
C56	5.76	0.21	0.19	24.33	0.004	0.014	0.567	0.050	1.23	0.58	0.89	6.24	1.75
C60	5.48	0.24	0.16	30.06	0.003	0.014	0.667	0.100	1.18	1.34	0.67	7.53	3.13
C61	5.08	0.22	0.16	24.33	0.002	0.023	0.188	0.050	1.25	1.25	0.56	13.06	3.00
C62	5.65	0.21	0.16	31.49	0.003	0.012	0.708	0.050	1.17	1.74	0.56	16.24	7.25
C63	4.52	0.05	0.12	31.49	0.004	0.040	0.883	0.033	0.75	0.75	1.44	17.88	5.13
C64	4.90	0.53	0.21	27.19	0.001	0.026	0.700	0.067	1.42	1.42	1.00	19.88	6.00
C65	4.22	0.16	0.19	27.19	0.002	0.008	0.842	0.050	1.32	1.30	0.44	11.35	5.75
C66	4.62	0.51	0.25	24.33	0.003	0.003	0.817	0.033	1.28	1.34	0.67	17.76	4.75
C67	5.42	0.56	0.21	30.06	0.001	0.014	0.833	0.033	1.48	1.67	0.89	13.88	6.38
C68	5.23	0.19	0.14	34.35	0.003	0.006	0.592	0.050	1.26	2.00	1.00	21.59	10.63
C69	5.72	0.40	0.16	21.47	0.002	0.014	0.950	0.033	1.40	1.59	0.78	16.29	5.68
C70	5.08	0.31	0.14	22.90	0.002	0.040	0.325	0.050	0.82	1.44	0.33	13.47	6.13
C71	4.71	0.14	0.16	24.33	0.001	0.006	0.092	0.067	0.76	1.11	1.44	11.29	2.75
C72	4.70	0.09	0.19	25.76	0.001	0.014	0.142	0.050	1.01	3.75	1.22	6.52	3.75
C73	5.08	0.58	0.16	34.35	0.002	0.083	0.600	0.050	1.13	1.96	0.44	19.18	11.75
C74	4.97	0.82	0.26	30.06	0.002	0.046	0.925	0.067	1,44	1.26	0.44	30.53	19.13
Average	**5.12**	**0.31**	**0.18**	**27.05**	**0.002**	**0.024**	**0.589**	**0.044**	**1.14**	**1.35**	**0.82**	**11.28**	**4.98**
SD	**0.51**	**0.02**	**0.003**	**3.90**	**0.0001**	**0.006**	**0.260**	**0.010**	**0.30**	**0.64**	**0.01**	**5.47**	**0.60**
CV %	**10.01**	**6.45**	**0.17**	**14.42**	**5.00**	**0.25**	**44.14**	**22.72**	**26.32**	**47.10**	**1.22**	**48.51**	**12.05**

Source: Field Work and Laboratory Analysis (2018)

From Table 4.2, the lowest pH level of 4.22 and higher pH of 6.03 are found at southern part, centre of the area, and are acidic in nature. The values were compared to soil fertility ranging from pH levels of 5.0 to 6.5 and the requirements for rice. Thus, it corresponds with the findings of Chude, Jayeoba and Berding (2012); Yusuf (2001) that soil pH values below 4.5. They added that soil pH levels of 6.1-6.5 are slightly acidic; soils are very fertile as well as meet the requirements for rice.

The soil properties in the area recorded higher Oc show value of 0.82%, N of 0.26 % and lowest Oc of 0.08% and N of 0.14% at the different part of the area. According to Essiet (1997); Chude, Jayeoba and Berding (2012) suggested that OC of less than 4.0% and N of less than 0.30% are classified as very low in terms of fertility levels. The co-efficient of variation in this regard show that there is no variation among the soil samples as pointed out by Adamu (2006) that co-efficient below 50% indicated little or no variation.

The values of phosphorus recorded highest of 34.35ppm, lowest of 21.47ppm and the mean of 27.05ppm. The co-efficient of variation 14.42% shows there is no variation among the soil samples. These values are moderate in fertility level as suggested by Essiet (1997); Chude, Jayeoba and Berding (2012) that available phosphorus ranging from 30-60ppm is at medium or moderate fertility class and ranging from 61-80 is at high fertility level. Therefore, available phosphorus in the area is at moderate fertility class and for rice requirements. Adopt standard and current units to discuss this result.

The result shows higher K of 0.083 cmol/kg, lowest K of 0.003 cmol/kg and the mean of 0.024 cmol/kg. The values are very low compared to the range of K below 0.3 cmol/kg very low, 0.3-0.7 cmol/kg moderate and 0.7-2.0 cmol/kg high for fertility class (Essiet, 1997; Chude, Jayeoba and Berding, 2012; Yusuf and Tukur, 2012). Cation exchange capacity (CEC) in the area recorded higher of 1.74 cmol/kg and the mean of 1.14 cmol/kg. The values were very low class and poor for crop cultivation. As suggested by Essiet (1997); Ayeni (2011) that CEC below 6.0 cmol/kg is classified as very low in fertility level. Thus, CEC values at Damari in this regard are at the very low in fertility class.

The result also shows the value of Cu 2.00 g/kg, of Fe 1.34 g/kg, of Zn 11.28 g/kg and of Mn 4.98g/kg at the centre of the area. The values are very high compared to Cu 0.24 g/kg, Fe 0.37 g/kg, 0.31 g/kg and Mn 0,01 g/kg of soils at Kabba and Ado-Ekiti (Babalola *et al.*, 2011). Thus, Esu *et al.* (2014) suggested that higher micronutrients influence low values in exchangeable bases in the soils. The values of Zn and Mn are very high compared to standard for rice and crop cultivation in the area and can lead to toxicity.

5. Conclusion

The study revealed the status of soil physical and chemical properties for fertility in the area. Soil properties including average clay fraction of 35.09% and phosphorus of 27.05 ppm are at moderate fertility class. The average pH of 5.12, Oc of 0.13%, N of 0.18%, P of 27.05ppm, K of 0.024cmol/kg and CEC of 1.14 cmol/kg are at very low fertility levels.

The average values of micronutrients including Zn of 11.28 g/kg and Mn of 4.98 g/kg respectively are very high compared to rice requirements. Considering the above findings, it can be concluded that the soils in the area are at low level in potentiality for rice cultivation. Therefore, measures should be taken in order to improve soil fertility for rice and other crop cultivation to address the problems of agricultural production and sustainable developments.

6. Recommendations

Based on the findings and conclusion of the study, the following recommendations could be made.

1. The soil fertility class involving clay and P is found to be at moderate levels. The use of chemical fertilizer is recommended to stabilize the levels of clay and Phosphorus. Thus, plants need these soil properties in large quantity to meet the requirements for growth and development.
2. The major soil properties including OC and N are found to be at very low levels compared to the rice requirements. The use of fertilizer organic is recommended to improve their level in the soil for intensive rice production in the area.
3. The soil micronutrients including Zn and Mn were found to be at higher level. The use of chemical fertilizer is recommended to balance the issue, because micronutrients are needed for plant growth and development in small quantity.

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