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RESEARCH ARTICLE

EVALUATION OF LAND FERTILITY STATUS IN TIRTOMOYO DISTRICT, WONOGIRI REGENCY, INDONESIA

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ABSTRACT

Evaluation of soil fertility status on agricultural is to know the fertility of soil chemically through soil analysis or soil test. This was done to obtain estimates data of land characteristics based on parameters observed and tested for various alternative uses based on specific objectives. Parameters used to assess soil fertility status were Cation Exchange Capacity (CEC); Bases Saturation (BS); Organic Carbon; Total P and K levels. Evaluation of soil fertility status is needed as an effort to know the potential and direction of the management of land production on the cultivation of agricultural crops, and to know the factor of fertility that limits on the land. Based on the above description, it is necessary to evaluate the status of soil fertility in Tirtomoyo District in order to be used in the effort to provide and increase food sustainability of Wonogiri region and able to increase the economy level and income of the farmers. The results showed that the soil fertility status in all areas of Tirtomoyo District classified into the low category. This was due to the low value shown in almost all observation parameters; Cation Exchange Capacity (CEC); Base Saturation (BS); Organic Carbon; Total P and K levels. The limiting factor of soil fertility status caused by a very low Total P value of 2.16 mg/100g to 14.19 mg/100g, and Organic Carbon which is low with 0.4% to 1.7%.

Keyword: Fertility, Organic Carbon, Total P

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INTRODUCTION

Human life can not be separated from the soil, all major food sources are grown from the Soil. The soil is a part of the earth's crust that comes from underground rock weathering processes that are under it which influenced by organism, climate, and time activities (Purwanto, Kusuma, & Suryono, 2015). The soil has a very important role in the survival of plants that grow on it because of the land supports the life of the plant by providing nutrients and water as well as the media for roots. Soil that desired by agriculture is fertile soil, while the fertile criteria are divided into three types: biology fertility, physic fertility, and chemical fertility.

Evaluation of soil fertility status on agricultural land is to assess the fertility of soil chemically through soil analysis or soil test. According to Ritung, Nugroho, Mulyani, & Suryani (2011), evaluation on land is generally a continuation of surveys and mapping of land or other land resources through an

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interpretation of soil and environmental data. This is done to obtain estimates of land characteristics based on parameters observed and tested for various alternative uses based on specific objectives. The parameters used to assess soil fertility status according to the technical guidance of soil fertility evaluation by Pusat Penelitian Tanah (1995) are Cation Exchange Capacity (CEC); Base Saturation (BS); Organic Carbon; Total P and K levels of soil.

The research location takes place was in Tirtomoyo District in Wonogiri Regency Central Java. Tirtomoyo District area is mostly used for agricultural land, according to Badan Pusat Statistik Kabupaten Wonogiri (2015) agricultural land on Tirtomoyo is 1806.17 ha used for paddy field and 2402.55 ha used for moorland from 9301.01 ha of its total area. Agricultural area in Tirtomoyo spread across hills, valleys and some on-slope area that dominated this region and uniquely made from various geology type according to Geology Map of Ponorogo and Pacitan Quadrangle by Sampurno & Samodra (1997).

Evaluation of soil fertility status is needed to know the potential and direction for both land management and production agricultural crops and to know the factor of fertility limit on the land. Based on the above description, it is necessary to evaluate the status of soil fertility in Tirtomoyo District in order to be used in the effort to provide and increase food sustainability for Wonogiri region and able to increase the economy level and income for the farmers. Research conducted to determine the status of soil fertility is an important thing in increasing crop production and affect agriculture in the present and the future.

MATERIALS AND METHODS

The research location is in Tirtomoyo District which the district center is located at 111^{o}3'54"E and 7^{o}56'58"S. Soil analysis for fertility status parameters was conducted at Soil Chemistry and Fertility Laboratory, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta. The research begins in September 2016 until February 2017.

The data materials used in the research include Soil Type Map (made in 2010) which is sourced from Balai Besar Litbang Sumberdaya Lahan Pertanian/ Indonesian Research and Development Center for Agricultural Land Resource (BBSDLP) Bogor and Earth Projection Map (made in 2001) for Tirtomoyo District covering by Bungur, Pulorejo and Nawangan Sheet sourced from the Badan Koordinasi Survey dan Pemetaan Nasional/ National Survey and Mapping Coordinating Departement (Bakosurtanal).

The research was conducted by explorative descriptive survey method through direct observation in the field supported by laboratory analysis. The analytical unit uses the Land Map Unit (LMU) obtained from the secondary data of the Soil Type Map sourced from the Indonesian Research and Development Center for Agricultural Land Resource (BBSDLP) processed using ArcGIS 10.1 application. Observation point (site sampling) is chosen by purposive sampling that is intentional to fit the research objectives.

Another important consideration of the determination of this sample point is the proportionality and representative of the required requirements and accessibility at the point to be studied. Each sample point is taken composite soil samples at a depth of 0-20 cm. The research work maps are presented in Figure 1.

Samples of composite soil that have been taken in the field, then analyzed their chemical properties in Soil Chemistry and Soil Fertility Laboratory, Faculty of Agriculture, Sebelas Maret University, Surakarta. Soil chemical analysis includes CEC and BS analysis (NH_4OAc Extract Method); Organic Carbon analysis (Walkley and Black Method); Total P and K analysis (25% HCl Extract Method) according to the reference from Eviati & Sulaeman (2012). Each parameter then set the criteria in accordance with the results obtained by analysis as in reference technical analysis for soil by Eviati & Sulaeman (2012). Determination of soil fertility status based on the technical guidance of soil fertility evaluation Soil Research Center Bogor (Pusat Penelitian Tanah, 1995).

RESULTS AND DISCUSSION

Sampling point consists of 1/1, 1/2, 1/3, 2/3, 4/1, 4/3 with the use of moorland, and then 2/1, 2/2, 3/1, 3/2, 3/3, 42 with the use of paddy field. The condition of sites sampling like altitude, slope, and main vegetation is presented in Table 1. The criteria of each soil parameters are determined using Table 2 accordance the reference technical analysis for soil by Eviati & Sulaeman (2012). The determination of soil fertility status based on Table 3 accordance with the technical guidance of soil fertility evaluation Soil Research Center Bogor (Pusat Penelitian Tanah, 1995).

The result of soil analysis and the combination of soil parameter analysis determines the criteria of soil fertility status is shown in Table 4. Based on the analysis of soil fertility status shown in Table 4, soil fertility status in Tirtomoyo district area for all observation points has the same fertility status that is low. The low fertility status in this region is due to the many limiting factors of parameter soil measurements. Scoring value of CEC at each observation point ranges from low to medium. This CEC value has a positive relationship with the low BS values.

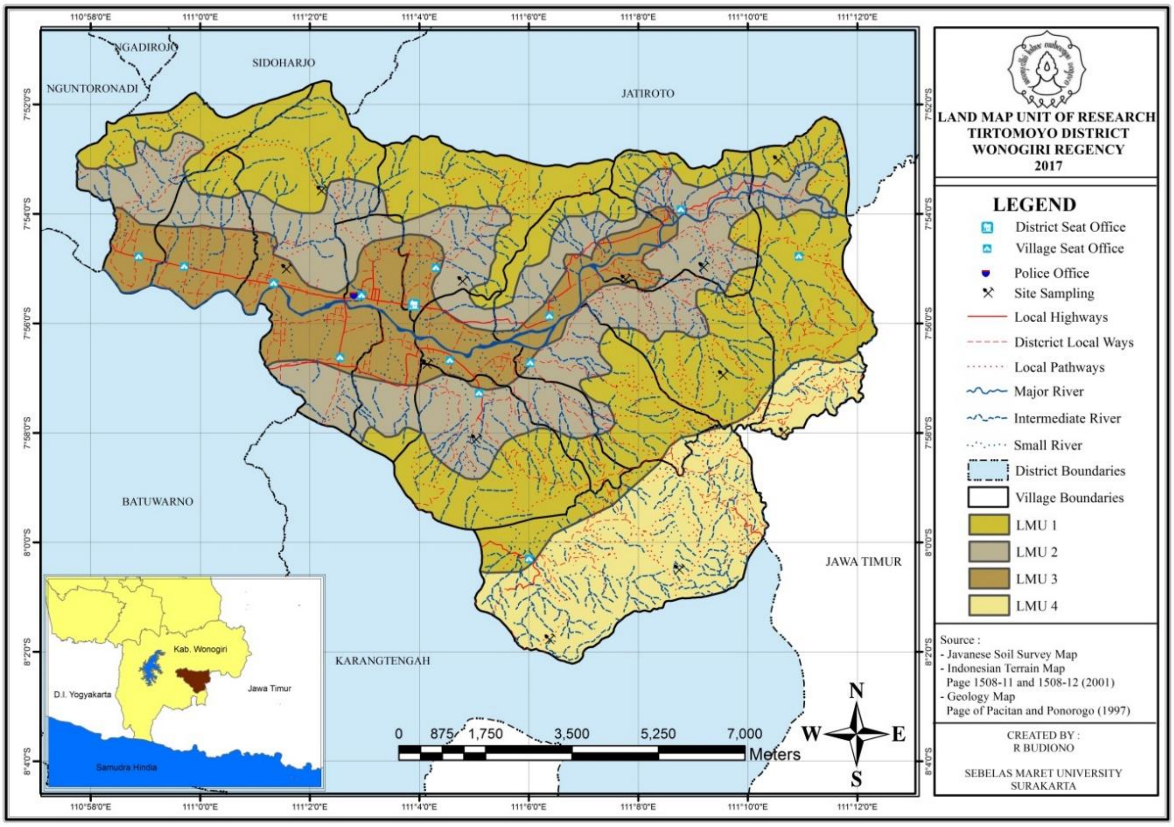

Figure 1. Land map unit in the research area

Table 1. The condition of sites sampling

Site	Coordinate Point	Altitude	Slope	Land use	Main Vegetation
1/1	7° 55’ 24.93” S; 111° 2’ 39.91” E	539 m	25 %	Moorland	Teak
1/2	7° 55’ 23.79” S; 111° 7' 55.23" E	489 m	37%	Moorland	Teak, Cassava
1/3	7° 57' 32.72" S; 111° 7' 11.01" E	455 m	0%	Moorland	Clove
2/1	7° 56' 15.71" S; 111° 4' 27.51" E	233 m	12%	Paddy field	Paddy
2/2	7° 56' 16.82" S; 111° 7' 05.80" E	312 m	10%	Paddy field	Paddy
2/3	7° 58' 21.57" S; 111° 4' 34.46" E	267 m	28%	Moorland	Teak, Curcuma
3/1	7° 56' 12.96" S; 111° 2' 07.06" E	187 m	0%	Paddy field	Paddy
3/2	7° 57' 36.87" S; 111° 4' 01.46" E	198 m	15%	Paddy field	Paddy
3/3	7° 56' 41.02" S; 111° 6' 15.86" E	270 m	8%	Paddy field	Paddy
4/1	8° 00' 14.50" S; 111° 4' 48.66" E	864 m	45%	Moorland	Cassava
4/2	7° 58' 59.50" S; 111° 7' 12.34" E	831 m	26%	Paddy field	Paddy
4/3	7° 58' 18.40" S; 111° 7' 53.43" E	891 m	26%	Moorland	Pine, Cassava

Table 2. Soil parameters criteria

Parameters	Very Low (VL)	Low (L)	Medium (M)	High (H)	Very High (VH)
Organic Carbon (%)	<1.0	1.0-2.0	2.0-3.0	3.0-5.0	>5.0
Total P (mg/100g)	<15	15-20	21-40	41-60	>60
Total K (mg/100g)	<10	10-20	21-40	41-60	>60
CEC (cmol$^{(+)}$/kg)	<5	5-16	17-24	25-40	>60
Base Saturation (%)	<20	20-40	41-60	61-80	81-100

Table 3. Soil Fertility Combination

No	CEC	BS	Total P, Total K, Organic Carbon	Fertility Status
1	H	H	H ≥ 2 without L	High
2	H	H	H ≥2 with L	Medium
3	H	H	M ≥2 without L	High
4	H	H	M ≥2 with L	Medium
5	H	H	H > M >L	Medium
6	H	H	L ≥2 with H	Medium
7	H	H	L ≥2 with M	Low
8	H	M	H ≥2 without L	High
9	H	M	H ≥2 with L	Medium
10	H	M	M ≥2	Medium
11	H	M	Another Combination	Low
12	H	L	H ≥2 without L	Medium
13	H	L	H ≥2 with L	Low
14	H	L	Another Combination	Low
15	M	H	H ≥2 without L	Medium
16	M	H	M ≥2 without L	Medium
17	M	H	Another Combination	Low
18	M	M	H ≥2 without L	Medium
19	M	M	M ≥2 without L	Medium
20	M	M	Another Combination	Low
21	M	L	3 H	Medium
22	M	L	Another Combination	Low
23	L	H	H ≥2 without L	Medium
24	L	H	H ≥2 with L	Low
25	L	H	M ≥2 without L	Medium
26	L	H	Another Combination	Low
27	L	M	H ≥2 without L	Medium
28	L	M	Another Combination	Low
29	L	L	All Combination	Low
30	VL	H, M, L	All Combination	Very Low

Table 4. The result of Analysis of Soil Fertility Status of Tirtomoyo District

Site sampling	Parameters	Av.Result	Units	Score	Fertility Status
1/1	CEC	24	me/100g	Medium	Low
	BS	31	%	Low	
	Organic Carbon	1.2	%	Low	
	Total P	2.16	mg/100g	Very Low	
	Total K	42.36	mg/100g	High	
1/2	CEC	20	me/100g	Medium	Low
	BS	41	%	Medium	
	Organic Carbon	1.0	%	Low	
	Total P	2.51	mg/100g	Very Low	
	Total K	16.32	mg/100g	Low	
1/3	CEC	19	me/100g	Medium	Low
	BS	29	%	Low	
	Organic Carbon	0.5	%	Very Low	
	Total P	13.85	mg/100g	Very Low	
	Total K	3.77	mg/100g	Very Low	
2/1	CEC	23	me/100g	Medium	Low
	BS	31	%	Low	
	Organic Carbon	1.7	%	Low	
	Total P	10.65	mg/100g	Very Low	
	Total K	9.68	mg/100g	Very Low	
2/2	CEC	16	me/100g	Low	Low
	BS	34	%	Low	
	Organic Carbon	1.2	%	Low	
	Total P	14.19	mg/100g	Very Low	
	Total K	14.91	mg/100g	Low	
2/3	CEC	15	me/100g	Low	Low
	BS	32	%	Low	
	Organic Carbon	0.9	%	Very Low	
	Total P	6.02	mg/100g	Very Low	
	Total K	32.85	mg/100g	Medium	
3/1	CEC	19	me/100g	Medium	Low
	BS	20	%	Low	
	Organic Carbon	1.1	%	Low	
	Total P	3.41	mg/100g	Very Low	
	Total K	5.34	mg/100g	Very Low	
3/2	CEC	24	me/100g	Medium	Low
	BS	34	%	Low	
	Organic Carbon	1.2	%	Low	
	Total P	11.79	mg/100g	Very Low	
	Total K	5.17	mg/100g	Very Low	
3/3	CEC	12	me/100g	Low	Low
	BS	52	%	High	
	Organic Carbon	0.4	%	Very Low	
	Total P	6.38	mg/100g	Very Low	
	Total K	15.61	mg/100g	Low	
4/1	CEC	24	me/100g	Medium	Low
	BS	28	%	Low	
	Organic Carbon	0.8	%	Very Low	
	Total P	3.40	mg/100g	Very Low	
	Total K	2.52	mg/100g	Very Low	
4/2	CEC	16	me/100g	Low	Low
	BS	28	%	Low	
	Organic Carbon	0.8	%	Very Low	
	Total P	9.27	mg/100g	Very Low	
	Total K	29.64	mg/100g	Medium	
4/3	CEC	12	me/100g	Low	Low
	BS	54	%	High	
	Organic Carbon	1.0	%	Low	
	Total P	5.65	mg/100g	Very Low	
	Total K	2.01	mg/100g	Very Low	

The data in Table 4 indicates that the BS values according to Eviati & Sulaeman (2012) are based on the extent through the NH_4OAc extract method belonging to the lower class. BS in the soil is determined by a large number of base cations present in the soil solution and the exchangeable complex. This low BS value is thought to be derived from the low base cations present in the soil solution characterized by soil pH which is close to the acid. This is reinforced by research from Dhananjaya & Ananthanarayana (2010) which states the distribution of BS values in inceptisols with a pH range of 5-6 is at 20-35%. The soils in Tirtomoyo according to USDA soil taxonomy mostly classified into Inceptisols because didn't find any specifically characterized horizon (such as argillic properties and others) and supported by laboratory analysis data by showing low The BS values of these lands.

The next factor is the C-Organic soil content, in Table 4 presents data from Organic Carbon in the Tirtomoyo District at very low to low levels. This may illustrate the lack of intake of organic matter on the soil or the amount of input of organic matter on the land cannot compensate for the amount of loss due to other factors such as being transported in the crop and carried away by erosion. The next factor is the low value of Total P. Total P at each observation point is very low, according to Eviati & Sulaeman (2012) the level of P_2O_5 on soil is categorized very low if it has less than 15 mg / 100g with HCl 25% extract analysis. The low value of Total P soil in each LMU is thought to have a close relationship with the low soil pH value of each LMU in the range 5.5-6.0 (slightly acid). This is supported by the opinion of Amisnaipa, Susila, Susanto, & Nursyamsi (2014) which states that in general, the limiting factor grows on any soil having a pH value close to acid one of which is the retention or lack of nutrient P content in the land. The low level of P content of nutrients on the ground either totally or readily has a relationship with pH, especially at the near-acid pH of element P will be strongly absorbed by acid oxides so that it becomes unavailable to plants such as $Al_x(PO_4)_y$ and $Fe_x(\ PO_4)_y$. Total K at each observation point also showed the same pattern as Total P, almost at all observation points (except for site 1/1 categorized as high, then site 2/3 and 4/2 both categorized as a medium) have very low to a low level. Low level of Total K is characterized by low soil pH value because the K-shaped element of oxide in the soil will carry the alkaline properties. The parent material in Tirtomoyo District according to Sampurno & Samodra (1997) comes largely from the Nglanggran formation, where the main rock composition of Nglanggran formation is the Andesite turbidite. Most of the Andesite constituent minerals are of the Plagioclase and Pyroxine / Hornblende types which have almost no K-content when they become soil. This is reinforced by Safei, Arian, & Mirhosseini (2015) which states that on the mineral Plagioclase type will be dominated by elements of ferro-allu-magnesia and other elements such as Ca and Na. The dominance of these elements is a substantial part of the constituent group of acid oxides in sesquioxides.

Efforts that can be done to improve fertility status on land in Tirtomoyo District most of them are by fertilization. Provision of fertilizer can be done by adding organic matter to the soil or the addition of other fertilizers. Provision of fertilization on land will increase the status of land fertility in accordance with the fertilizer issue given, according to research conducted by Zörb, Senbayram, & Peiter (2014) fertilization is one of the most visible ways to increase the availability of K nutrients on soils. Other efforts that can be done to overcome this limiting factor other than an addition to fertilization can also be done by adding ameliorant such as biochar. This is in line with a study conducted by Liu, Meng, & Jiang (2017) which states that the addition of biochar-based from rice husks can increase the availability of P on soils that have a pH tend to be acidic. Another study conducted by Zhang, Chen, & Gray (2016) also stated that the addition of biochar has a positive effect in increasing the availability of P on soils other than by direct fertilization. Variations of materials in biochar manufacture also have different effects on the availability of P. According to research by Zhang et al. (2016) biochar species that have the potential to increase the availability of P most of the nine species of biochar studied are biochar based from Sword-grass (*Imperata cylindrical*). Another type of grass that has potential as biochar is Red Clover grass (*Trifolium pretense*). According to research conducted by Oram, Voorde, & Ouwehan (2014) states that Red Clover grass has considerable potential in increasing the availability of K on the soil.

CONCLUSION

Based on the results of research and discussion that has been done in the previous chapter it can be concluded that at all points of observation scattered in District Tirtomoyo have the same fertility status that is low. The low level of soil fertility status is caused by the low and very low level of all fertility measurement parameters; CEC, BS, Organic Carbon, Total P and Total K. Efforts that can be done to overcome this problem is with the adding of organic matters, fertilizers, and ameliorant.

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