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Analysis of Soil Quality Index of mixed garden land use type on dry land in Blang Bintang sub-district, Aceh Besar district

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ABSTRACT

This research was conducted by using a descriptive method based on the results of surveys and field observations and laboratory analysis. Field survey activities were carried out to obtain primary data in the form of general biophysical conditions of the area and physical and chemical characteristics of the soil obtained from observations and indicators of soil quality through soil analysis in the laboratory. Soil sampling points were determined using the purposive sampling method, namely points that have been determined in selected dry land areas in Blang Bintang District, Aceh Besar District. Soil sampling for analysis of chemical properties was carried out by drilling. Soil drilling was carried out to determine the thickness of the soil solum. Sampling was focused only on the top soil layer with a thickness of 0 - 20 cm. In mixed garden land use type (LUT) 5 - 6 sample points were taken which were then analyzed in the laboratory. From the data from the soil analysis, the fertility status of each type of land use will be determined. Field observations and sampling were carried out at each observation point (LUT) in the Blang Bintang District, Aceh Besar District.The soil characteristics and a large percentage of sand compared to the percentage of silt and clay. The low content of clay fraction in both lands affected the formation of soil aggregates. The position and composition of organic matter greatly determine the process of forming stability and distribution of aggregates. Sandy soil in mixed garden vegetation is difficult to absorb water and nutrients due to large grains and small surface area per unit weight. The soil which is dominated by the sand fraction is porous with high aeration pores. Smooth aeration properties can increase the oxidationof organic matter.
Keywords**:** *Soil qulity index, dry land, Aceh Besar*

1. INTRODUCTION

Dry land is a stretch of land that has never been inundated or flooded at some time of the year or all the time (Sukarman et al., 2012). Although the potential for dry land in general in Aceh and particularly in the district of Aceh Besar is relatively wide, the optimization of dry land for food crop development is still low. This is due to several obstacles faced, including the lack of data and information regarding soil quality from several types of soil in the dry land of Aceh Besar district .

Therefore, efforts to increase land productivity to support the development of food crop cultivation are still not significant (Sufardi et al., 2016). Naturally, soil organic matter levels in the tropics rapidly decline, reaching 30-60% within 10 years (Suriadikarta et al., 2002). Therefore, a good soil management effort is needed (based on the parameters of soil chemical fertility) meaning that it is in accordance with the needs for the types of plants being cultivated. To formulate appropriate actions, these goals can be achieved. Firstly, it is necessary to know the status of soil fertility. Therefore, it can be known the chemical nature of the soil which is a limiting factor in each area. This can be done by evaluating soil fertility. This is a diagnosis of nutrient problems in the soil and determine the type and amount of nutrients needed (fertilization). One method that is often used in assessing the fertility of a soil is through an approach with soil analysis or soil sample testing (Melsted and Peck, 1972).

Land use change affects soil organic matter input (Guo et al., 2017), canopy structure and soil moisture and nutrient migration (Sakin, 2014, Six and Paustian, 2014), which in turn alters soil nutrient intensity, rate, and cycle pathways. , which in turn affects soil properties and quality (Hu et al., 2018). Agricultural management practices and land use changes can change the physical, chemical, and biological properties of soil (Qi et al., 2018), which are determinants of soil quality (Marzaioli et al., 2010). Changes in land use and management are also associated with increased carbon emissions; conversion of forests to agricultural land has reduced global soil organic carbon (SOC) storage by 31–52% (Wang et al., 2017).

Deforestation, particularly in terms of conversion to high-production agriculture, greatly affects soil quality (Davaria et al., 2020). Reduced biomass inputs lead to reduced SOC and total nitrogen (TN) (Bakhshandeh et al., 2019). In addition, tillage affects the physical and chemical characteristics of the soil (Zuber et al., 2017, Barbosa et al., 2019), including bulk density (BD) (Korkanç, 2014) and electrical conductivity (EC), and has been shown to be associated with an increase in pH (Davaria et al., 2020), a decrease in TN (Wang et al., 2016a) and an increase in soil microbial respiration (Bayranvand et al., 2017). Tilling also promotes the loss of SOC; Surface soil layers can lose up to half of their organic carbon through tillage (Gelaw et al., 2014, Soleimani et al., 2019, Huang et al., 2021).

Soil quality is a general term that combines physical, chemical and biological parameters. These aspects of soil are interdependent and may respond differently to changes in land use. Therefore, individual parameters may be indicators of poor soil quality (Mukherjee and Lal, 2014, Davaria et al., 2020). Instead, a more holistic methodological approach should be used to assess change (Raiesi, 2017). Currently, comprehensive methods for evaluating soil quality include qualitative (eg visual), semi-quantitative (Doran and Parkin, 1994), and quantitative (Andrews et al., 2002, Davaria et al., 2020) methods. The difference between semi-quantitative and quantitative is how to get the minimum data set. The semi-quantitative method is to select the minimum data set from the total data set through expert opinion, and the quantitative method is to extract the minimum data set through statistical methods, for example, principal component analysis, multiple correlation, factor analysis (Andrews et al., 2002). Quantitative assessment of soil quality is usually achieved through laboratory analysis of physical, chemical, and biological parameters, combined with soil quality indices (SQIs) (Marzaioli et al., 2010). SQI can be determined through standard scoring function, nonlinear scoring function, or linear scoring function method (Li et al., 2020), where the SQI value represents soil quality. In general, SQI is easy to use and offers flexibility (Leite Chaves et al., 2017, Huang et al., 2021).

Soil quality indicators are properties, characteristics or physical, chemical and biological processes of soil that can describe soil conditions (SQI, 2001). Karlen et al. (1997) stated that the selection of soil quality indicators should reflect the capacity of the soil to perform its functions. Based on the function of the land to be assessed, several appropriate indicators are selected. According to Mausbach and Seybold (1998), the selection of indicators is based on the concept of a minimum data set (MDS), which is as little as possible but can meet the needs. To give an accurate description of the soil quality in dry land it is necessary to conduct studies on soil quality through direct observation in the field through surveys and laboratory tests to determine the soil quality index on dry land (Martunis and Sufardi, 2016).

Soil quality is the ability of the soil to provide nutrients for plants, maintain and increase water and air in the soil, and support human needs (Doran et al., 1994). There are several reasons that lead to the decline in soil quality, including the change in land use type from forest to agricultural land (Oguike and Mbagwu, 2009) and the consequences of intensive land use (Jamala and Oke, 2013). Improved soil quality due to various types of land use or crop rotation can be measured by changes in soil indicators and other parameters (Pham et al., 2018).

The most popular indicators used to assess soil quality are soil organic carbon (SOC), total nitrogen (TN) and soil acidity (pH). Soil organic carbon is very important for soil fertility and is a strong indicator of soil biological health (Chan et al., 2010) as well as its chemical, biological and physical processes. Total nitrogen is the main nutrient used for vegetation growth and is also used as a key soil quality assessment (Ren et al., 2014). Soil pH is the most important indicator in managing agricultural production. Most agricultural crops thrive in soils with a pH of 5.5 to 6.5 . (Pham et al., 2018).

Doran and Parkin (1994) define soil quality as the capacity of a soil to function within ecosystem boundaries to preserve biological productivity, maintain environmental quality, and improve plant and animal health. Johnson et al.(1997) proposed that soil quality is a measure of soil condition compared to the needs of one or several species or to several human needs.

Soil quality is measured based on observations of dynamic conditions of soil quality indicators. Measurement of soil quality indicators produces a soil quality index. Soil quality index is an index calculated based on the value and weight of each soil quality indicator. Soil quality indicators are selected from the characteristics that indicate the functional capacity of the soil.

Soil quality indicators are properties, characteristics or physical, chemical and biological processes of soil that can describe soil conditions (SQI, 2001). According to Doran and Parkin (1994), soil quality indicators must (1) show the processes occurring in the ecosystem, (2) combine soil physical properties, soil chemistry and soil biological processes, (3) be acceptable to many users and can be applied to a wide range of land conditions, (4) sensitive to variations in soil management and climate change, and (5) where possible, the property is a component commonly observed in soil databases.

The type of land use is very important for all types of soil to maintain soil fertility. In mixed gardens, the C-organic content was higher (2.17%) when compared to Imperata (2.10%) and dry fields (1.92%) due to the greater diversity of vegetation in mixed gardens, while for On dry land planted with seasonal crops, namely corn, soybeans, and cassava, almost all parts of the plant are carried away by the harvest, so that very little organic matter is returned to the soil and is added from the effects of intensive tillage. Each soil has a different organic matter content according to the characteristics of the soil and the use of the land. Changes in vegetation or land use and soil management patterns cause changes in soil organic matter content (Yasin, 2007). Therefore, this study is to examine the analysis of the soil quality index on the type of mixed garden land use on dry land in the Blang Bintang sub-district, Aceh Besar district.

2. RESEARCH METHODS

This research was conducted in Blang Bintang District, Aceh Besar District, Aceh Province which is geographically located between 5.20 - 5.80 North Latitude and 95080' - 950.88' East Longitude with an area of 2,969 km2 or 296,900 ha. This study focused on several field observation points in agricultural areas and other uses on several types of dry land use in Blang Bintang District, Aceh Besar District. In addition to the field, this research was also conducted at the Soil and Plant Research Laboratory, Faculty of Agriculture, Syiah Kuala University.

The equipment used in the field were gps, soil drill, sample ring, pH meter, meter, plastic, rubber, knife, hoe, and *Abney* level. While the equipment used in the laboratory for soil analysis were analytical balance, pH meter, oven, shaker, hot plate, hogonizer, distillation unit, burette, beaker, spectrophotometer and AAS (*Atamic Absorption Spectrophotometer*). The materials used in this study include soil taken from the top layer (0 - 20 cm) for evaluation of soil fertility status. Other materials included regional maps, google maps, maps of soil types, maps of observation points and various chemicals that would be used during soil surveys in the field such as 10% H2O2, 10 N HCl, distilled water and materials for laboratory analysis.

This research was carried out using a descriptive method based on the results of surveys and field observations (*field study*) and laboratory analysis. Field survey activities were carried out to obtain primary data in the form of general biophysical conditions of the area and physical and chemical characteristics of the soil obtained from observations and indicators of soil quality through soil analysis in the laboratory.

Soil sampling points were determined using the purposive *sampling method*, namely points that have been determined in selected dry land areas in Blang Bintang District, Aceh Besar District. Soil sampling for analysis of chemical properties was carried out by drilling. Soil drilling was carried out to determine the thickness of the soil solum. Sampling was focused only on the top soil layer with a thickness of 0 - 20 cm. In mixed garden vegetation (LUT) 5 - 6 sample points were taken which were then analyzed in the laboratory. From the data from the soil analysis, the fertility status of each type of land use would be determined. Field observations and sampling were carried out at each observation point (LUT) in the Blang Bintang District, Aceh Besar District. Soil samples were taken at a slope of 0 to 15% (flat to slightly steep) representing Entisol and Inceptisol soil types.

Soil sample analysis was conducted in the laboratory to obtain information on the chemical and physical properties of the soil at the research site. The variables analyzed included: pH (H2O), C-Organic, N-Total, P-available, K-switched. For data on the value of cation exchange capacity (CEC) and base saturation (KB) were used as data to support soil classification. Meanwhile, the analysis of the physical properties of the soil from a single undisturbed soil sample was size fraction (texture), volume weight and porosity as well as soil respiration. Aspects and methods of analysis of chemical properties, soil physics and root depth can be described in Table 2.

Table 1. Physical, Chemical and Biological Properties of Soil were analyzed in the Laboratory

No	Aspect Analysis		Analysis Method
1	Texture (Three Factions)	%	Pipette Method of Stoke's Law
2	Reaction (pH) soil: pH (H_2O)		electrometric
3	C-Organic	%	Walkey dan Black
4	N-total	%	Kjeldahl
5	P-available	ppm	Bray dan Olsen
6.	K-dd	cmol kg^{-1}	Extraction 1 N NH_4COOH
7.	Rooth depth	cm	Driling (earth drill)
8.	Volume Weight (*Bulk density*)	g m^{-3}	Sample ring (*core method*)
9.	Porosity	%	Total Saturation
10.	Soil Respiration	mg C-CO_2 g^{-1} hari $^{-1}$	Verstraete modification method

Source: Soil and Plant Laboratory and Biology Laboratory, Faculty of Agriculture, Syiah Kuala University (2015)

Analysis of the soil quality index used the Mausbach and Seybold (1998) method modified by Partoyo (2005). Determination of the soil quality index was based on the nine criteria of soil properties in table two above. Modifications were made by Partoyo (2005) and Arifin (2011), in some respects according to the conditions of the research land. The criteria for soil quality according to Partoyo was presented in table 4 below.

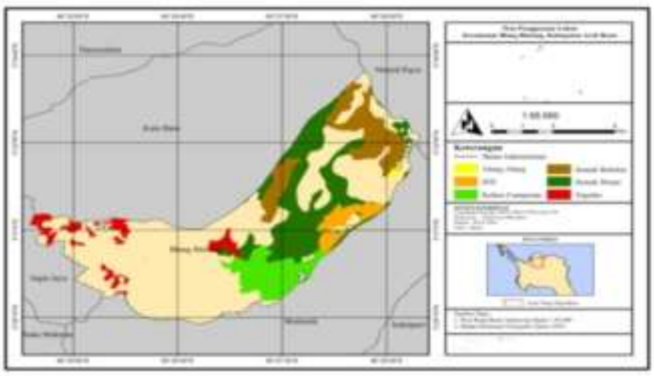
Table 2. Soil quality criteria based on soil quality index values (IKT)

No	Class Value IKT	Soil Quality Criteria
1	0,80– 1,00	Very good (SB)
2	0,60– 0,79	Good (B)
3	0,40– 0,59	Medium(S)
4	0,20– 0,39	Low (R)
5	0,00– 0,19	Very Low (SR)

Source: Partoyo(2005)

The map of the research location to determine the soil quality index on the type of mixed garden land use in Blang Bintang sub-district, Aceh Besar district can be seen in Figure 1.

Figure1. Map of research locations on mixed garden land use types in Blang Bintang sub-district, Aceh Besar district



RESULTS AND DISCUSSION

Soil quality index (IKT) can be known from the results of field observations and laboratory analysis. Based on observations and descriptions of soil profiles in several locations, the survey was made to represent mixed garden vegetation on dry land in Blang Bintang sub-district, Aceh Besar district.

Table 3. Modification of soil indicators, weight index and boundaries of the assessment function (Mixed Gardens)

Function of land	Weight I	Soil Indicator	Weight II	Weight III	Index Weight	Rating Function				Value	Score	IKT
						Under Under		Limit On				
						X_1	Y_1	X_2	Y_2			
1	2	3	4	5	6	7	8	9	10	11	12	13
Preserve												
biological	0.4	Rooting Medium	0.33									
Activity		Rooting depth(cm)		0.6	0.079	5	0	180	1	155.97	0.863	0.068
		Volume weight of soil (g cm^{-3})		0.4	0.053	2.1	0	0.5	1	1.28	0.513	0.027
		Humidity	0.33									
		Total porosity (%)		0.2	0.026	20	0	80	1	32.15	0.203	0.005
		C-organic (%)		0.4	0.053	0.2	0	3	1	3.47	1.168	0.062
		Dust-Clay (%)		0.4	0.053	0	0	100	1	20.83	0.208	0.011
		Harassment	0.33									
		pH		0.1	0.013	4	0	8	1	6.47	0.618	0.008
		P-available(mg kg^{-1})		0.2	0.026	2.5	0	50	1	2.50	-	-
		K-dd (cmol kg^{-1})		0.2	0.026	0.01	0	1	1	1.85	1.859	0.048
		C-organic (%)		0.3	0.040	0.2	0	3	1	3.47	1.168	0.047
		N-total (%)		0.2	0.026	0.2	0	5.2	1	0.20	-	-
		Total A										**0.276**
Arrangement &		Dust-clay (%)	0.60		0.18	0	0	100	1	20.83	0.208	0.037
water	0.3	Total porosity (%)	0.20		0.06	20	0	80	1	32.15	0.203	0.012
Distribution		Soil volume (g cm^{-3})	0.20		0.06	2.1	0	0.5	1	1.28	0.513	0.031
		Total B										**0.08**
Filter & Buffer		Dust-clay(%)	0.60		0.18	0	0	100	1	20.83	0.208	0.037
	0.3	Total porosity (%)	0.10		0.03	20	0	80	1	32.15	0.203	0.006
		Proses Mikrobiologis	0.30									
		C-organic (%)		0.5	0.045	0.2	0	3	1	3.47	1.168	0.053
		N-total (%)		0.5	0.045	0.2	0	5.2	1	0.20	-	-
		Total C										**0.096**
Total												**0.453**
Criteria												Medium

Soil quality is the ability of the soil to carry out its very important function in playing the role of controlling surface flow and supporting plant growth. Soil management practices are often required to maintain soil quality after use (USDA, 2007). Soil quality index was calculated by multiplying the weight index and the score from the indicators of soil physical, chemical and biological properties. The higher the IKT value, the better the soil quality or carried out its functions better (Mausbach and Seybold, 1998, Andrewsetal., 2004).

One of the reasons for the moderate soil quality index in mixed garden vegetation is due to soil sampling on the inceptisol soil type in the Blang Bintang sub-district, which has less fertile soil characteristics. Inceptisols are known to have low levels of essential nutrients, especially nitrogen (N), phosphorus (P), and potassium (K). Intensive soil management can cause soil damage in terms of properties, physics, chemistry, and soil biology. Damage to soil chemical properties can occur due to the acidification process caused by the continuous use of large amounts of artificial nitrogen fertilizers (Brady, 1990; Buckman & Brady. 1982). Physical soil damage can be in the form of damage to soil structure that causes compost due to the use of inappropriate agricultural mechanization tools or the continuous use of chemical fertilizers. Biological damage is characterized by population shrinkage or reduced biodiversity of soil organisms which is usually the result of damage to physical and/or chemical properties (Sufardi et al 2012).

In mixed garden vegetation, the percentage of sand was compared to the percentage of silt and clay. The low content of clay fraction in both lands affected the formation of soil aggregates. The position and composition of organic matter greatly determined the process of forming stability and distribution of aggregates (Nurida and Kurnia, 2009; Juarsah, 2016). Sandy soil in mixed garden vegetation was difficult to absorb water and nutrients because of the large grains and small surface area per unit weight. The soil which was dominated by the sand fraction is porous with high aeration pores. Smooth aeration properties could increase the oxidation of organic matter.

This was in line with Afriani and Juansyah (2016) stating that the dominant soil of the sand fraction had low water holding capacity and low organic matter content. Clay had a large surface area per unit weight. Therefore it had the ability to hold water and provided high nutrients. Fine-textured soils were more active in chemical reactions than coarse-textured soils (Naharuddin et al., 2020). Another thing that caused the low IKT in mixed garden vegetation was the porosity value of 31.63% which was included in the poor porosity category.

4. CONCLUSIONS

The soil quality index of mixed garden vegetation in Blang Bintang sub-district, Aceh Besar district was classified as moderate. This was due to soil sampling on inceptisol soil types in the Blang Bintang sub-district, which had characteristics of less fertile soil and a large percentage of sand compared to the percentage of silt and clay. The low content of clay fraction in both lands affected the formation of soil aggregates. The position and composition of organic matter greatly determined the process of formation of stability and distribution of aggregates. Sandy soil in mixed garden vegetation was difficult to absorb water and nutrients because of the large grains and small surface area per unit weight. The soil which was dominated by the sand fraction is porous with high aeration pores. Smooth aeration properties could increase the oxidation of organic matter.

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