Analysis of Physical and Biological Characteristics of Dryland Soil at Karieng Village, Grong-Grong Subdistrict

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Abstract. The potential for developing dry land is still very low, particularly in Karieng Village. One step that can be taken is to improve the physical and biological properties of the soil. This research was conducted to identify several characteristics of dry land and aims to enhance the physical and biological properties of the soil in Karieng Village, Grong-Grong District. The study employed a descriptive-quantitative method, focusing on the physical and biological soil properties. The observed parameters included soil color, texture, structure, porosity, moisture content, bulk density, and the number of soil microorganisms. The results indicated soil colors classified as Olive Black, Dark Brown, Brown, and Brownish Black. Soil texture was classified as silt and clayey silt. Soil structure was categorized as angular clod, clod, crumb, and granule. Soil porosity ranged from good to very poor. Moisture content was between 5,93% and 8,46%. Bulk density was classified as mineral soil, and total microorganisms ranged from 1,85-4,45 (x 10^5 SPK/g BKM soil).

Keywords: land characteristics, soil physics, soil biology, dry land

1 Introduction

Grong-Grong District is one of the districts in Pidie Regency, with a population of 7,289 and an area of 21,00 km², including 430 ha of rice fields and 916 ha of dry land. Meanwhile, Karieng Village has a population of 801 and an area of 3,00 km², with 18 ha of rice fields and 179 ha of dry land [2]. The organic farming system prioritizes the use of organic materials as a requirement in agricultural activities. The use of organic materials is expected to improve the physical, chemical, and biological properties of the soil, thereby supporting better plant growth. Research on changes in soil properties is crucial to ensure future use [8]. Dry land refers to areas that are not flooded or inundated for most of the year. The term is often used interchangeably with upland, dryland, or unirrigated land, with the latter terms indicating land used for rainfed agriculture. Upland refers to land located at a higher elevation that is cultivated without water inundation, unlike rice paddies [11]. The physical properties of soil significantly influence the

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availability of water, soil air, and indirectly affect the availability of plant nutrients. These properties also impact the soil's potential for maximum productivity [10].

2 Method

This study was conducted in Karieng Village, Grong-Grong District. The materials used included administrative maps, soil types, slopes, land use maps, land unit maps, 10% H_2O_2, distilled water, and 1 N HCl for field observations, along with administrative maps and land unit maps (SPL). The tools used in this research included a GPS (Global Positioning System), Munsell soil color chart, and other supporting equipment. The method employed in this study is descriptive-quantitative, involving field observations. Land unit points (SPL) were determined for soil sampling and subsequent laboratory analysis.

2.1 Preparation

Secondary data from relevant government agencies related to this study, such as climate data, specifically rainfall data from the last 10 years, which will be obtained from the Grong-Grong District Agricultural Extension Office (BPP). This phase also included administrative maps of the district, soil type maps, slope maps, land use maps, and other information related to the conditions of the research area.

2.2 Pre-Survey and Survey

The initial stage of field activities involved determining observation points through drilling at different slopes, followed by selecting the pedon points to be observed. Coordinates were taken to establish the position of the profile points using GPS. The physical properties of the soil were observed at these soil profiles.

2.3 Observations

Soil Sampling Technique. Soil samples were taken at each observation point based on the 6 SPLs. Each SPL involved digging a profile for soil observation, followed by analysis of the soil samples.

Soil Profile Observation. Observation began with measuring the depth of the profile from the top layer to the bottom. The boundaries of the horizons or soil layers were determined by observing differences in color or density. Density differences were assessed by inserting a knife into the soil with consistent pressure, followed by establishing horizon boundaries and recording their depths in a profile form. The parameters for physical and biological properties are detailed in the following table.

Table 1. Analysis of Physical and Biological Soil Properties

No.	Parameter	Method Used
1	Soil Color	*Munsell Soil Colour Chart*
2	Soil Texture	Soil Finger Test (thumb and index finger)
3	Soil Structure	Aggregate Observation
4	Porosity	Saturation
5	Moisture Content	Gravimetrik
6	Bulk Density	Ring Sample
7	Soil Microorganism Count	Pour Plate

3 Results and Discussion

3.1 Characteristics of the Research Location

Grong-Grong Subdistrict is one of the subdistricts in Pidie Regency with a population of 7,289 and an area of 21,00 km², which includes 430 hectares of paddy fields and 916 hectares of dry land. Meanwhile, Karieng Village has an area of 3,00 km² with a population of 801, comprising 18 hectares of paddy fields and 179 hectares of dry land (Central Bureau of Statistics, 2020). The sampling and morphological observation points for Karieng Village are presented in the table below.

Table 2. Morphological Characteristics for Each Land Map Unit

SPL	Soil Type	Elevation	Slope	Topography
1	Aluvial	8 mdpl	0-3 %	Flat
2	Regosol	11 mdpl	0-3 %	Flat
3	Aluvial	8 mdpl	0-3 %	Flat
4	Litosol	18 mdpl	3-8 %	Hilly
5	Litosol	13 mdpl	0-3 %	Flat
6	Litosol	9 mdpl	0-3 %	Flat

Source: Field Observation Data, Karieng Village

The table above describes the sampling and observation points, which feature a variety of soil types, including alluvial, regosol, and lithosol. The sampling points range in elevation from 8 meters above sea level (mdpl) to 18 mdpl, with flat topography (slope of 0-3%) to hilly terrain (slope of 3-8%). For the six Land Units (SPL) observed, profile digging was conducted at SPL 4 and SPL 6.

Rainfall data was obtained from the Agricultural Extension Office of Gong-Grong Subdistrict in Pidie Regency over a 10-year period from 2011 to 2020. The average annual rainfall over this period was 1,369.90 mm, with an average of 93,8 rainy days, 5,7 wet months per year, and 2,6 dry months per year. The rainfall data can be seen in Table 3.

Table 3. Rainfall data

No	year	Rainfall (mm)	Rainy Days (hh)	Wet Months (bulan)	Dry Months (bu-lan)
1	2011	1367,5	115	6	2
2	2012	1131,4	107	4	3
3	2013	1435,5	95	7	3
4	2014	1632,5	86	6	2
5	2015	1320,5	122	6	2
6	2016	1413,5	100	5	5
7	2017	1593	79	7	3
8	2018	1238	75	6	2
9	2019	1005	80	4	1
10	2020	1646	79	6	3
	Total	6849,5	938	57	26
	Aver-age	1.369,90	93,8	5,7	2,6

Source: Agricultural Extension Office BPP of Grong-Grong Subdistrict (2020)

Based on the data in Table 3, the climate classification can be determined using the Q value, which is the ratio of the average number of dry months to wet months, according to the Schmit and Ferguson formula. With a Q value of 42%, and referencing the Schmit-Ferguson triangle, Pidie Regency, specifically Grong-Grong Subdistrict, falls into Type C. This indicates a climate of moderately humid areas with forest vegetation, characterized by deciduous trees during the dry season.

3.2 Characteristics of Soil Physical Properties

The parameters of soil physical properties observed in this study include soil color, soil structure, soil texture, porosity, moisture content, and bulk density, which were analyzed in the laboratory. For the biological properties, only the total microorganisms were assessed through tests conducted in the Soil Biology Laboratory.

Soil Color. The soil color at the research site in the topsoil layer varies: SPL 1 and 3 show olive black (5Y 3/1 and 5Y 3/2), SPL 2 is dark reddish brown (5YR 3/3), and SPL 4 is brown (10 YR 4/4). SPL 5 exhibits dark brown (10 YR 3/4), while SPL 6 is brownish black (7.5 YR 3/2). In the subsoil layer, SPL 1 has olive brown (2.5Y 4/6), SPL 2 and 6 are dark brown (10YR 4/4), SPL 3 is dark olive (5Y 4/4), SPL 4 is dark brown (10 YR 3/4), and SPL 5 is brown (10 YR 4/6).

Soil color is indicative of various soil properties, as it is influenced by several factors present in the soil. In areas of low agricultural production, the dominant soil color tends to be yellowish brown, attributed to organic matter content undergoing leaching. Conversely, in high-production areas, the soil is predominantly orange due to the presence of geothite minerals. The differences in color across layers result from variations in organic matter and mineral content; darker soils indicate higher geothite content, while redder soils suggest higher hematite content [6].

Soil Structure. The soil structure of the topsoil layer has a clumpy structure in SPL 3 and 5, an angular clumpy structure in SPL 1, a crumbly structure in SPL 2, a grainy structure in SPL 4 and 6, while the subsoil layer has a clumpy structure in SPL 5, an angular clumpy structure in SPL 1,3,4 and 6, a crumbly structure in SPL 2. Soil structure is the particles of soil particles such as sand, dust, and clay that form aggregates with other soil aggregates. In other words, soil structure is related to soil aggregates and the stability of soil aggregates. Organic matter is closely related to soil aggregate stability because organic matter acts as an adhesive between primary mineral particles [12].

Soil Texture. The topsoil layer has a dust texture class at SPL 1, 2, 3 and 5, the dusty clay texture class is found at SPL4 and SPL 6. While the subsoil layer has a dusty clay texture class at SPL 1, 4 and 6, the dust texture class is found at SPL 2, 3 and 5. The texture class grouping is based on the USDA soil texture class triangle diagram. Soil texture is the ratio between the fractions of sand, dust, clay, thus showing the coarseness or fineness of a soil. Soil texture is an important parameter related to, among others, earase, drainage, the ability to store and provide water for plants [1].

Soil Porosity. The porosity values in the topsoil layer range from good (51.36% in SPL 1) to poor (39.58%, 39.49%, and 38.78% in SPL 3, 4, and 6). SPL 2 and 5 are rated as fair (49.22% and 46.91%). In the subsoil layer, porosity is classified as poor (39.85%, 33.23%, and 38.02% in SPL 1, 3, and 4) and fair (49.93%, 48.62%, and 48.67% in SPL 2, 5, and 6). The highest porosity is found in mixed stands at 47.04%, while the lowest is in open stands at 46.04%. Porosity indicates the percentage of pore space in the soil, reflecting its ability to absorb water quickly [3].

Soil Moisture Content. Soil moisture content in the topsoil ranges from 6.61% to 8.46% across different SPLs, while in the subsoil, it ranges from 5,93% to 7,99%. Soil moisture content indicates the amount of water in the soil, usually expressed as a percentage. Higher organic matter content increases moisture retention, while sandy soils have lower total pore space but can efficiently transmit water [7]. Normal soil moisture content is around 2.54%, influenced by finer textures that retain more water compared to coarser textures [4].

Bulk Density. Bulk density in the topsoil ranges from 1,12 g/cm^3 to 1,36 g/cm^3, and in the subsoil, it ranges from 1,10 g/cm^3 to 1,43 g/cm^3. According to Hardjowigono, bulk densities of 0 to 0,99 g/cm^3 indicate peat soils, while 1,0 to 2,0 g/cm^3 are classified as mineral soils [5]. Thus, the soils in this study are classified as mineral. Bulk density indicates soil compaction; higher densities mean more difficulty for water movement and root penetration. Typically, bulk density ranges from 1,1 to 1,6 g/cm³, and it reflects the difference between the weight of dry soil and its volume, including pore space [13].

3.3 Characteristics of Soil Biological Properties

Total *Microorganisms*

Total soil microorganisms in the topsoil layer ranged from 2.23-44.5 SPK/g BKM soil, while the subsoil layer ranged from 1.85-3.780 SPK/g BKM soil. According to Hanafiah, the influence of soil biota, both macro and micro to the preparation of the soil body, soil fertility, fertility of plants growing on it and the environment is very important [4]. Currently, various soil biological attributes are widely used as indicators of soil quality and health. Microorganism biomass is an index of soil fertility. Soils that contain a wide variety of microorganisms can generally be said to have good physical and chemical properties. High populations of microorganisms and a variety of microorganisms can only be found in soils that have properties that allow soil microorganisms to develop and be active. The availability of sufficient nutrients, appropriate soil pH, good aeration and drainage, sufficient water and sufficient energy sources (organic matter) are some of the factors that must be met so that soil micro-organisms can grow and develop [9].

4 Conclusion

Soil physical properties from field observations in Karieng Village include soil color that varies from Olive black, Brownish black, Brown. The soil structure is characterized by crumb, grain, clod. While the soil texture consists of dusty loam to dust. The results of laboratory analysis of soil physical properties in Karieng Village also show the value of moisture content of 5.93-8.46%, soil porosity is good to poor, soil volume weight is mineral soil (1,0 – 2,0 g/cm3), and total microorganisms range from 1,85-4,45 (x 105 SPK/g BKM).

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