



Analysis of Soil Physical Properties and Their Implications for Corn (*Zea mays* L.) Land Management in Pulubala District

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Abstract

*This study aims to analyze variations in soil physical properties and their implications for corn (*Zea mays* L.) land management strategies in Pulubala District. This study used a quantitative descriptive survey method on three systematically selected corn land units, with soil sampling at a depth of 0-20 cm for analysis of texture, water content, bulk density, particle density, and porosity in the laboratory. The results showed that points 1 and 3 have a sandy loam texture with a dominant sand content, while point 2 has a clay texture with a dominant clay fraction. The bulk density and porosity values illustrate the gradation of soil compaction, where point 1 is relatively looser with high porosity, while points 2 and 3 show lower porosity and indications of compaction that inhibits aeration and root penetration. In terms of management, land with good physical conditions needs to focus on maintaining soil structure, while more compacted land requires intervention in the form of adding organic matter, improving aeration, and regulating drainage to maintain an optimal corn growing environment.*

Keywords: Soil physical properties, soil fertility, corn, management

INTRODUCTION

Corn fields in Pulubala District play a crucial role in supporting corn production in Gorontalo Province due to their substantial land area. However, this increased productivity is not fully supported by basic information on the physical properties of the soil in the local corn fields, even though soil properties are a key determinant of corn crop success.

In general, the physical fertility of soil is determined by a combination of texture, water





content, bulk density, particle density, and porosity which together regulate the movement of water, air, and root development in the soil.(Utomo et al., 2016)Physical soil fertility primarily consists of soil texture, water content, bulk density, particle density, and porosity. Soil texture, in the form of the proportions of sand, silt, and clay, can affect the soil's ability to absorb water and nutrients.(Rizal et al., 2022), Soil water content can determine the availability of water for plants(Gulo & Hia, 2024), bulk density affects pore space, aeration, and plant root growth(Waruwu & Buulolo, 2024)Soil particle density shows the level of compaction of soil pores which will determine the process of entry of water and plant roots(Minangkabau et al., 2020), and soil porosity has an influence on plant growth, affects surface flow and erosion.

In Pulubala District, corn field management practices are generally general and not based heavily on site-specific soil physical characteristics. Farmers tend to use uniform tillage and fertilization patterns across plots, without considering differences in soil texture and compaction levels between plots, potentially reducing input efficiency and accelerating soil physical degradation. This situation highlights the need for more focused studies on the actual physical properties of soil.

Several previous studies have shown that analyzing soil physical properties, such as texture, bulk density, and porosity, can provide important information regarding the level of compaction and the soil's ability to supply water to plants. This information is essential for formulating soil management recommendations to support corn growth. Based on these conditions, research is needed that specifically examines the physical properties of soil in corn fields in Pulubala District. This study is expected to provide an overview of the physical fertility status of the soil and its implications for corn field management, thus providing the basis for developing soil management recommendations to maintain and increase corn productivity in Pulubala District.

METHOD

Analysis of soil physical properties was conducted at the Soil Science Laboratory, Faculty of Agriculture, Gorontalo State University (water content, bulk density, Particle density, porosity) and the Soil Science Laboratory, Faculty of Agriculture, Hasanuddin University, Makassar (texture analysis) in September – October 2025. This study used a quantitative descriptive survey method that aims to describe the physical properties at several corn plant locations in Pulubala District based on texture, water content, bulk density, Particle density, and porosity parameters. Data were obtained through direct measurements in the field and laboratory analysis of soil samples taken in corn field units. The study was conducted on





harvested corn fields, located at 3 land unit points taken as representatives.

The field tools used include GPS to determine the coordinates of the sample points, sample rings for collecting whole soil samples, hoes and shovels, sample plastic, labels, stationery, and a mobile phone for documentation. In the laboratory, a 105° oven, analytical balance, soil sieve, hydrometer for texture analysis, pycnometer for soil particle density, as well as measuring cups and other equipment for sample preparation and use are used. The main materials are soil samples from corn fields, distilled water/aquadest, and other chemicals for texture analysis.

The study employed a survey method with a systematic land unit-based approach. The corn area in Pulubala District was first divided into several land units. Three main land units were selected from these land units, representing corn fields. Each was represented by a 100 m x 100 m sampling area with a depth of 0–20 cm. Soil sampling points were determined using a diagonal pattern. Whole soil samples were taken, consistent with the analysis objectives.

RESULTS AND DISCUSSION

Area Description

Pulubala District is a sub-district in Gorontalo Regency, Gorontalo Province. This region is geographically dominated by rural areas, with the primary activities of the population being agriculture and plantations. Administratively, Pulubala District consists of 11 villages: Mulonegoro Village, Bakti Village, Pulubala Village, Tridarma Village, Pongongaila Village, Puncak Village, Molamahu Village, Molalahu Village, Toydito Village, Ayumolingo Village, and Bukit Aren Village.

Based on a survey at the research area location, there are 19 land units in Pulubala District, land that is actively used by farmers was selected, namely 3 land unit points based on the consideration that the three locations have similarities in land use (corn plants) with large planting areas and geomorphology.

Analysis of Soil Physical Properties

Based on the results of laboratory analysis, the physical properties of the soil in corn fields in Pulubala District are:



Table 1. Analysis of Soil Physical Properties in Corn Plantation Land in Pulubala District

Sample	Texture (%)				Water	bulk	Particle	Soil
Name	Sand	Dust	Look	Texture Class	content (%)	density (BD)	density (PD)	Porosity
Point 1	57	27	16	Sandy Loam	29	1.3	2.6	52
Point 2	27	31	42	Look	49	1.6	2.2	26
Point 3	56	27	17	Sandy Loam	25	1.5	2.0	25

Source: Research Results (2025)

Physical Properties of Soil

The analysis results in Table 1 indicate that the soil at point 1 has a sandy loam texture class, with a predominance of sand fractions compared to silt and clay. Bulk density is low to moderate, while porosity is relatively high. Meanwhile, soil water content is in the moderate range, generally indicating fairly loose soil conditions with adequate pore space for corn root development.

At point 2, the soil texture is classified as clay, with a significantly higher clay fraction than at other points. Bulk density is higher and total porosity is much lower compared to point

1. Meanwhile, the soil water content is relatively high due to the clay's high water-holding capacity. This condition indicates denser soil with limited aeration space despite high groundwater availability.
2. The soil at point 3 is classified as sandy loam with a high sand content, similar to point 1 but with a higher bulk density and lower porosity. The soil water content is moderate, but the combination of sandy texture and increased density indicates physical compaction, which reduces effective pore capacity.

Implications of Texture and Porosity on Water Availability

The differences in texture at the three points directly affect the soil's ability to retain and supply water to corn plants. The sandy loam soil at points 1 and 3 has better drainage and a lower risk of waterlogging than the clay soil at point 2, but its water-holding capacity is lower, making it more susceptible to drought when rainfall is low or irrigation is limited. Conversely, the clay soil at point 2 can retain more water, but some of this water is tightly held in micropores, making it less readily available to plants and potentially leading to water-saturated conditions during the rainy season. According to Utomo et al., (2016) Clay soil textures tend to form stable aggregates and have better nutrient retention. In sandy loam soil (point 1), the proportion of sand



allows for easier water and root movement, while in clay soil (point 2), the presence of a dominant clay fraction can inhibit root movement if the soil is too compact.

High porosity at point 1 indicates a more balanced proportion of macropores and mesopores, thus supporting air and water movement, as well as better root development. Low porosity values at points 2 and 3 indicate a dominance of pores that are less effective for aeration, potentially hindering oxygen diffusion to the root zone and increasing the risk of root stress, especially if accompanied by high rainfall or intensive soil cultivation. Research resultsSafira (2019), shows that high porosity is influenced by the size of the soil's Bulk Density and Particle Density. A decrease in soil porosity will cause a decrease in water infiltration, air flow, nutrient availability in the soil, and root branching. However, it should also be noted that the dominance of sand fractions has the potential to cause the soil to dry out quickly and be less able to retain nutrients if the organic matter is low, so in terms of management, an improvement step that can be taken is to add organic materials that can increase the soil's pore space.

The role of bulk density on Corn Root Growth

Bulk density is a primary indicator of soil compaction, and research results show a gradation from relatively low values at point 1 to higher values at points 2 and 3. A lower bulk density value at point 1 indicates a more crumbly and loose soil structure, allowing corn roots to more easily penetrate the soil layer and explore a larger soil volume to absorb water and nutrients. This is in line with research.Wang et al. (2015), which reported that optimal corn root growth occurs in soil with a Bulk Density value of $<1.3 \text{ g/cm}^3$. Point 1, with a value of 1.3 g/cm^3 in sandy loam soil, is still within the general range considered comfortable for corn rooting, due to its high porosity (52%). Conversely, high Bulk Density at points 2 and 3 indicates mechanical resistance to root penetration.

In the clay soil at point 2, this compaction is exacerbated by the plastic nature of the clay, making it easily compacted and difficult to work with when wet, and hard and cracked when dry. This can limit the depth of the corn root system, making the roots shallower and more susceptible to fluctuations in soil moisture. This means that even with high total water availability, the plant's utilization efficiency is suboptimal. At point 3, the soil has a sandy loam texture and a bulk density of 1.5 g/cm^3 , but its porosity is approximately the same as the soil at point 2 (25%). This indicates that even with a lighter soil texture, it can experience a compacted soil structure due to improper management, limiting root growth space and air flow.Widodo & Kusuma (2018), explained that without an adequate supply of organic matter, sandy loam soil can quickly compact, increasing bulk density, increasing aggregates, and reducing macropores.





Widodo also concluded that, compared to the control treatment, the addition of organic matter in the form of compost can result in looser soil structure, increasing soil pores, which in turn facilitates plant root growth.

Implications of Corn Land Management

Differences in physical properties found at three corn fields in Pulubala District suggest the need for specific land management. At site 1, with relatively good physical conditions, management strategies can focus on maintaining soil structure through the addition of organic matter and conservation tillage to prevent increased bulk density and decreased porosity. At site 2, management priorities are reducing clay compaction and improving aeration, for example by providing sufficient organic matter, implementing minimum tillage with the addition of cover crops, and managing drainage to prevent prolonged soil saturation. Research Hasibuan (2015), explains that the addition of organic matter in the form of compost significantly increases total porosity, reduces particle density, lump density, and soil permeability. Particle density is influenced by the type of minerals that make up the soil. This is similar to research Salawangi et al., (2020), explains that organic matter plays a crucial role in the formation of soil aggregates. Although aggregates do not directly affect plant growth, their presence can create physical conditions that support root development. This is particularly evident in their effects on porosity, aeration, the soil's ability to absorb and transmit water, and its water-holding capacity.

At point 3, indicating a combination of sandy clay texture with higher compaction, processing needs to be directed at improving the aggregate structure and increasing macropores through organic material input, use of mulch and planting pattern arrangements that reduce surface compaction.

CONCLUSION

This study shows that the physical properties of the soil at three corn fields in Pulubala District vary in terms of texture, water content, bulk density, particle density, and porosity, resulting in different growing environments for corn. Overall, the results of this study confirm that although all three locations are used for corn cultivation, the physical conditions of the soil differ, and soil management should be tailored to the physical characteristics of the soil at each site.





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