SOIL FERTILITY MAPPING OF CORN PLANT BASED ON MINERALS IN JENEPONTO REGENCY

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ABSTRACT

One of the efforts to optimize the growth and production of corn is by potential mapping areas for its development. Minerals are the main elements that have an important role in soil formation and determine the physical and chemical properties of the soil. Minerals are one of the essential indicators related to soil weathering, so the presence or absence of minerals in the soil can indicate how soil formation occurs, especially soil fertility on the land. Jeneponto is one of the corn-producing districts in South Sulawesi, so it is imperative to map its soil fertility based on soil mineral content to be sustainable. The research method used purposive sampling on cornfields in Jeneponto Regency. Soil mineral analysis was carried out using a thin section method, while the analysis of the physical and chemical properties of the soil, including pH, C-organic, and soil texture, followed the BPT procedure; the map was generated using the weighting method and processed by kriging. The results showed that the pH value of the soil was in the slightly acidic to neutral range; C-organic soil had low status in the eastern area and moderate status in the western area of the study site. The soil texture is dominated by clay, silty clay, and silty clay loam. The dominant easily weathered minerals are calcite, pyroxene, and hornblende. Soil fertility status based on nutrient-carrying minerals is in the moderate to the good range with a value of 55-75%. The potential for developing corn plants with priority status is in the Districts of West Bangkala and Bangkala. The second priority is in the Districts of Tamalatea, Batang, Kelara, Rumbia, and parts of Bontoramba, Tarowang, and Arungkeke.

Keywords: Jeneponto, soil, mineral, corn, map

INTRODUCTION

Corn is one of the agricultural commodities favored by the community. The Planting Area Expansion and Cropping Index Improvement Program can increase corn production because the wider the planted area, the more corn plants are produced to increase corn production (Purwanto, 2016). It can only be achieved if corn plants grow optimally (Mulyani, Nursyamsi, & Las, 2014). One of the efforts to optimize the growth of corn is by potential mapping areas for sustainable development.

The potential for soil fertility is strongly influenced by the parent rock and parent material (Weil & Brady, 2016). The mineral content in the weathered parent rock will affect the physical and chemical properties of the soil formed. Minerals in the soil will always be different in each region (Churchman & Lowe, 2012). However, the composition of the soil minerals has a very important meaning in terms of soil management. Soil that has a high non-resistant mineral content will have a high reserve of nutrient sources. On the other hand, if the soil is dominated by resistant mineral content the soil, the nutrient reserves in the soil are lacking and will affect the potential fertility of the soil (Bali, I., Ahmad, A. and Lopulisa, 2018). Minerals are the main elements that have an essential role in forming soil and determining the physical and chemical properties of the soil. Minerals are one of the important indicators related to the development of soil weathering processes, so the presence or absence of minerals in the soil can be used to indicate how soil formation occurs. (Hardjowigeno, 2016).

Based on the ease of the weathering process, minerals are divided into two, namely non-resistant minerals and resistant minerals (not easily weathered) (Wilson, 2004). The group of non-resistant minerals is minerals Ca-Na feldspar, ferromagnesian such as olivine, pyroxene, amphibole, and volcanic glass, while those included in the group of resistant minerals include quartz, orthoclase, muscovite. A ferromagnesian mineral group is a group of mineral sources of Ca, Mg, Na, and Fe in the soil. Non-resistant minerals can be used as indicators of potential soil fertility (Nasir, Jayadi, & Ahmad, 2021).

Increasing the production of corn crop commodities needs to be done by looking at the potential of the region so that it can be sustainable. Therefore, this research needs to be done so that the optimization of tropical farming systems can be achieved.

METHODOLOGY

Study Site

Jeneponto regency is a unique area because it is included in a dry area, but some of its territory in the eastern part has a slightly wet climate. Jeneponto is one of the largest corn-producing districts, with a relatively flat topography in the south and hilly to mountainous in the north. The complete location of the observations can be seen in Figure 1.

The rock formations that construct the research location, according to (Sukamto & Supriatna, 1982), consist of six rock formations (Figure 2), namely: 1) Qac: Quarter alluvial and coastal deposits (gravel, sand, mud, coral, and limestone); 2) Qlv: Quarter Lompobattang Vulcanic (conglomerate, lava, breccia, lava deposits, and tuff), which consists of several divisions, namely;

Qlvb (breccia, lava, and tuff) and Qlvp (parasitic eruptive products, mainly andesitic lava); 3) Temt: Tertiary Eocene-Miocene Tonasa consisting of limestone; 4) Tpbl: Baturape-Cindako Pliocene Tertiary lava and Tpbv: Baturape-Cindako Pliocene Tertiary (lava, breccia, tuff, and conglomerate).

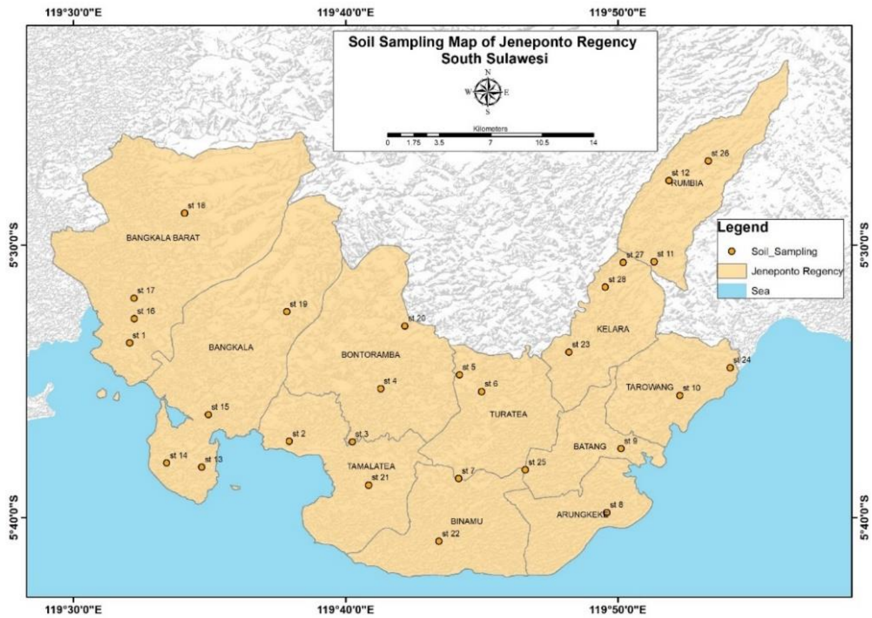

Figure 1. Study location and soil sampling in Jeneponto regency

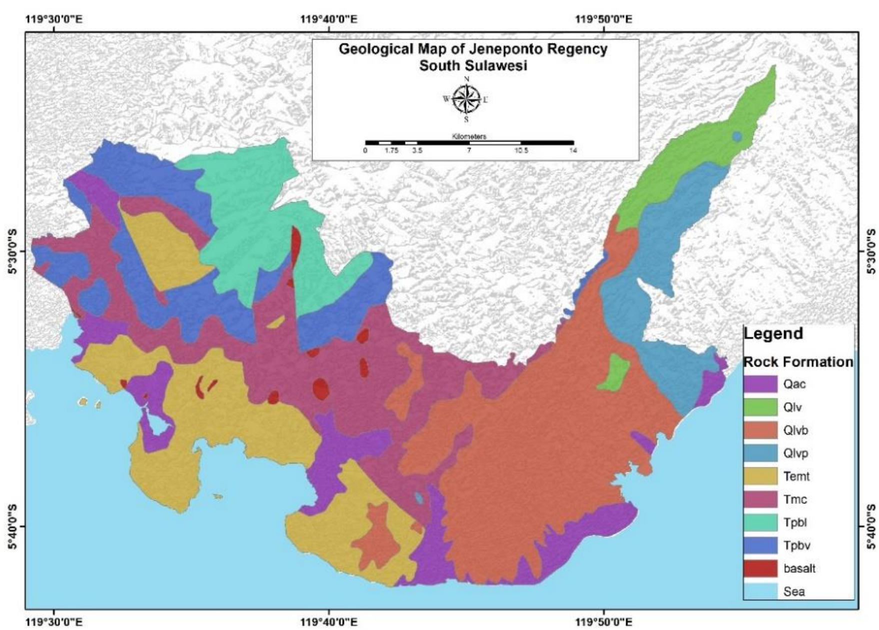

Figure 2. Geological map of Jeneponto regency

Materials and Methods

Observation and soil sampling were carried out in Jeneponto Regency (Figure 1). Analysis of pH and C-organic using the procedures of the Balai Penelitian Tanah (BPT, 2010). Analysis of soil minerals was carried out at the Geochemical and Mineralogy Laboratory, Department of Geological Engineering, Faculty of Engineering, Hasanuddin University. The tools used in this research are GPS (Global Position System), a set of survey tools, a camera, a computer, ArcGIS 10.3, Olympus BX41 type polarizing microscope for soil minerals.

Stages of Preparation and Mineral Identification

Mineral analysis of the parent material was carried out by the petrographic method by using the thin section method (Benyarku and Stoops, 2005). The process of making preparations (thin section) and mineral observation, namely :

a. Impregnating rock samples with epoxy fluids and resin (1:1)
b. Preparation of a parent material sample with a size of 0,001-0,003 mm, the incision results were observed using a polarizing microscope.
c. Identify minerals using the Kerr method (Kerr, 1959) with plane polarize (ppl), and cross polarize (xpl) observation.

Mineral Potential Assessment

In this stage, the calculation of the number of minerals in one field of observation is assumed to be 100% which is called the mineral counting method after knowing the results of mineral identification in each parent material. This process includes the percentage of weatherable minerals and resistant minerals, then the presence of minerals is presented. According to Notohadiprawiro (1983) the method of assessing nutrient reserves in the soil its necessary to know. Apart from Soil Taxonomy, quartz mineral differentiation is carried out in estimating weathered mineral content (nutrient reserves), namely :

$$\textbf{Mineral reserves} = \mathbf{100 - \%\ quartz}$$

After knowing the percentage of weathered minerals, an assessment of the potential for soil fertility is carried out by looking at the criteria in assessing the potential for soil fertility (Table 1).

Table 1. Mineral potential assessment criteria

Weathered Minerals	Term
100% - 70%	Good
70% - 40%	Moderate
40% - 0%	Low

(Notohadiprawiro, 1983)

Soil Fertility Mapping

Maps of soil fertility based on pH, C-organic and easily weathered mineral reserves using the simple kriging interpolation method with the equation (Kis, 2016; Kleijnen, 2017):

$$y(h)= \frac{1}{2N(h)} \text{ x } \sum_{n=1}^{N(h)} (Zn \ - Zn + h)^2 \qquad (1)$$

where:

N(h) is the number of data pairs at a distance of h

Zn is valuing at location n

Zn+h is valuing at location n+h

RESULTS AND DISCUSSION

Soil Characteristic

The dominance of soil texture in the Jeneponto Regency is clay, silty clay, and silty clay loam (Amin, Lias, and Ahmad, 2021). Soil C-organic content was at a moderate to a low level (Figure 3). The 0.9% of C-organic content was found in some Turatea Districts, Tarowang Districts, Arungkeke Districts, and Binamu Districts. The highest value of C-organic content of 4.1% was found in parts of West Bangkala and Bangkala District, especially in the southern part of this district from the parent rock of the Tonasa Formation (Tet). The dominant soil pH value was slightly acidic to neutral, with the lowest value being 6.02 and the highest being 6.9 (Figure 4). The distribution of soil pH with slightly acidic criteria spreads to the eastern part of Jeneponto Regency, and soil pH with a neutral category spreads to the western part of Jeneponto Regency (Figure 4). The decrease in C-organic value and soil pH in the Jeneponto Regency area in the east is influenced by the increasing rainfall pattern in the east Jeneponto Regency (Amin, Lias, and Ahmad, 2021). According to (BBPPSDL, 2011) corn plants are very suitable for developing areas with a pH value of 5.8-7.8 and an organic c value of > 1.2%. Based on the soil pH value, all Districts in Jeneponto Regency are suitable for developing corn plants, while based on the c-organic value of the soil, the priority scale for corn plant development is Bangkala and West Bangkala Districts. The second scale for the development of maize is the Districts of Tamalatea, Batang, Kelara, Rumbia, and part of the Districts of Bontoramba, Tarowang, and Arungkeke.

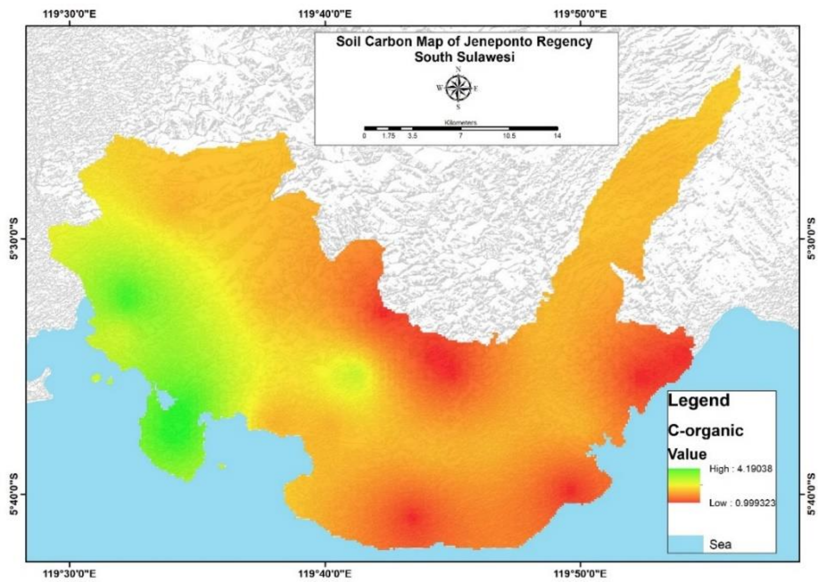

Figure 3. Soil carbon map of Jeneponto regency

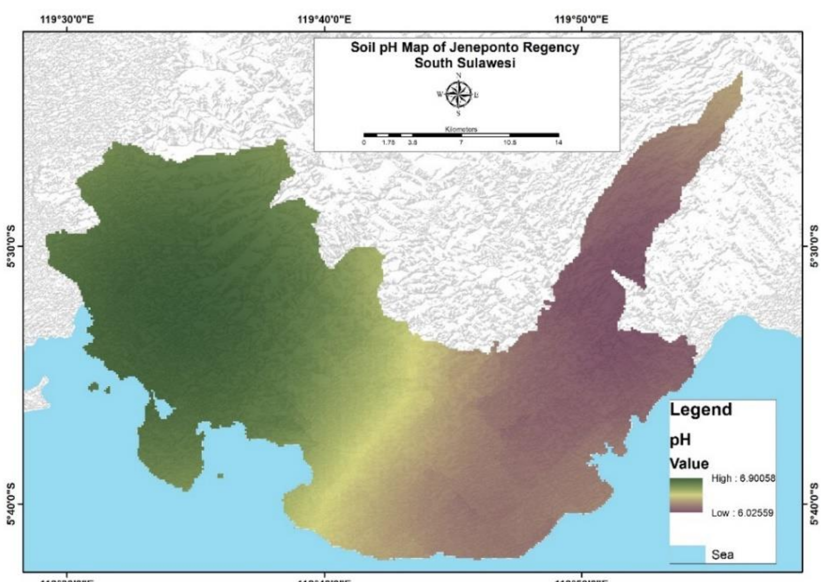

Figure 4. Soil pH map of Jeneponto regency

Soil mineral content of the parent material of the Qa Formation is found in pyroxene and hornblende minerals. Minerals undergo high weathering, marked by decreased mineral birefringence, mineral crystal destruction, and mineral transformation into nodules/iron oxide (Figure 5). Nutrient-carrying mineral reserves are in the range of 55-65%. The decrease in the potential content of soil minerals as a source of soil nutrients was found in Arungkeke District, reaching the range of 30%, with the remaining minerals being quartz and K-feldspar (Figure 6).

Soil sourced from the Qlv Rock Formation has moderate to good soil mineral potential. The mineral content is easily weathered in the range of 55-77%. The predominantly weathered minerals found were pyroxene and hornblende, while the dominant ones found were K-feldspar and nodules/oxides (Figure 7). The formation of nodules/oxides in the soil is found in quite large numbers, it can be attributed to the increased intensity of rainfall in the Rumbia District which increases the intensity of oxidation-reduction in the soil (Stoops, 2018).

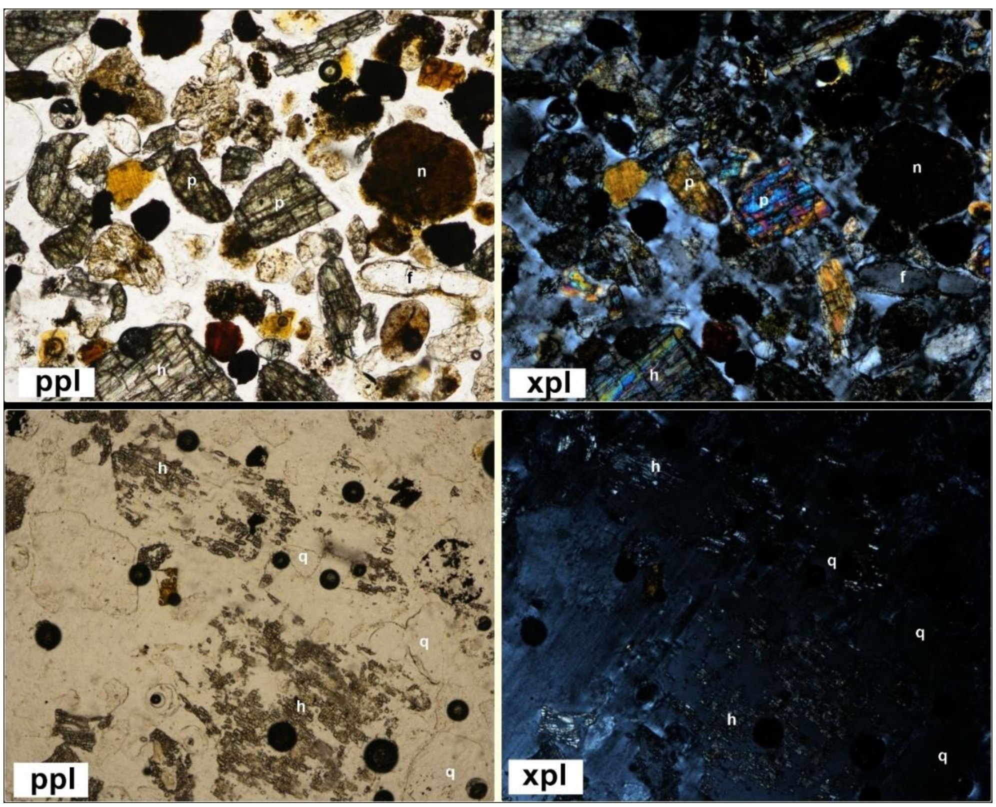

Figure 5. The appearance of soil minerals from the parent material Qa with the dominant non-resistant minerals consisting of pyroxene (p) and hornblende (h), while the resistant minerals are quartz (q) and nodules (n). Size 100µm

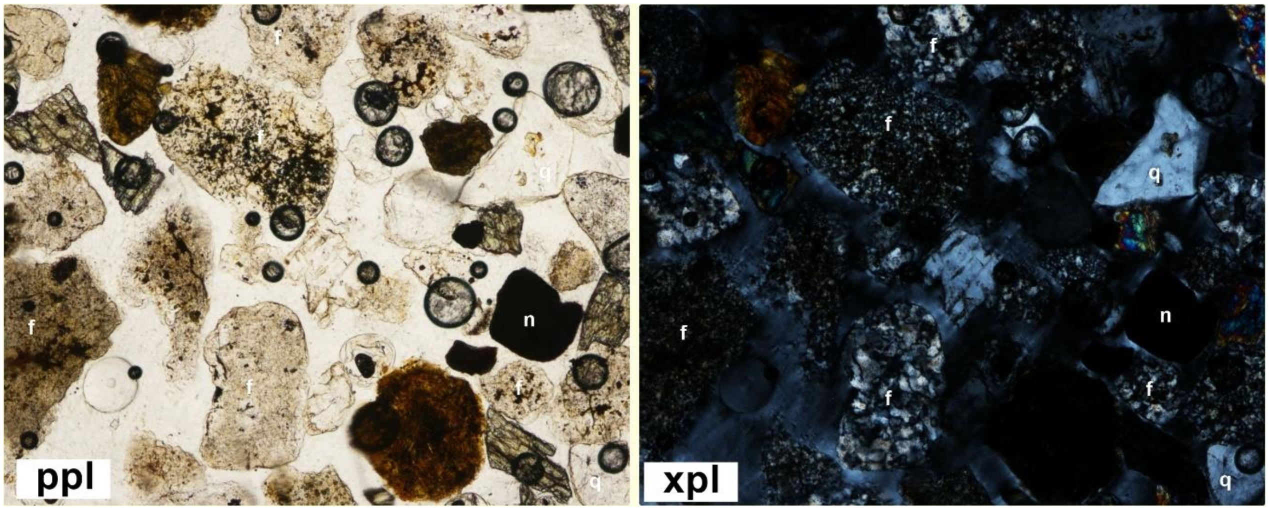

Figure 6. The appearance of soil minerals from the parent material Qa with the dominant minerals consisting of quartz (q), feldspar (f), and nodules (n). Size 100µm

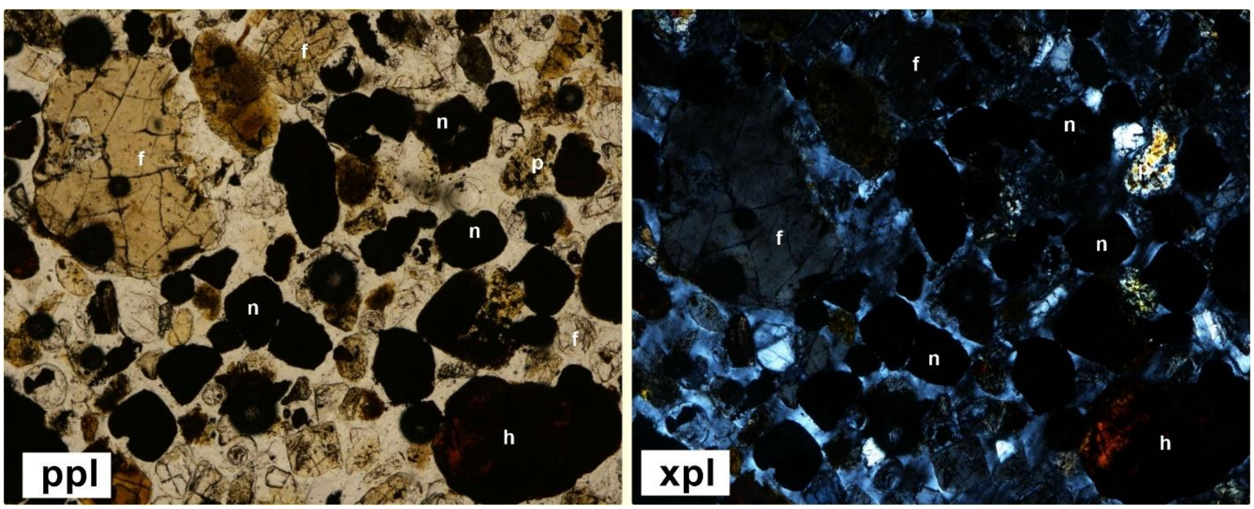

Figure 7. Soil mineral appearance from Qlv parent material with dominant minerals consisting of pyroxene (p), hornblende (h), feldspar (f), and nodules (n). Size 100µm

The mineral content of easily weathered soil from the Qlvp Rock Formation with andesitic lava type is dominated by hornblende minerals. In contrast, resistant minerals are dominated by K-feldspar and quartz minerals (Figure 8). The mineral content of easily weathered is 55-75% in the medium to good category. Minerals undergo a strong weathering process, characterized by the formation of nodules with completely altered nodules.

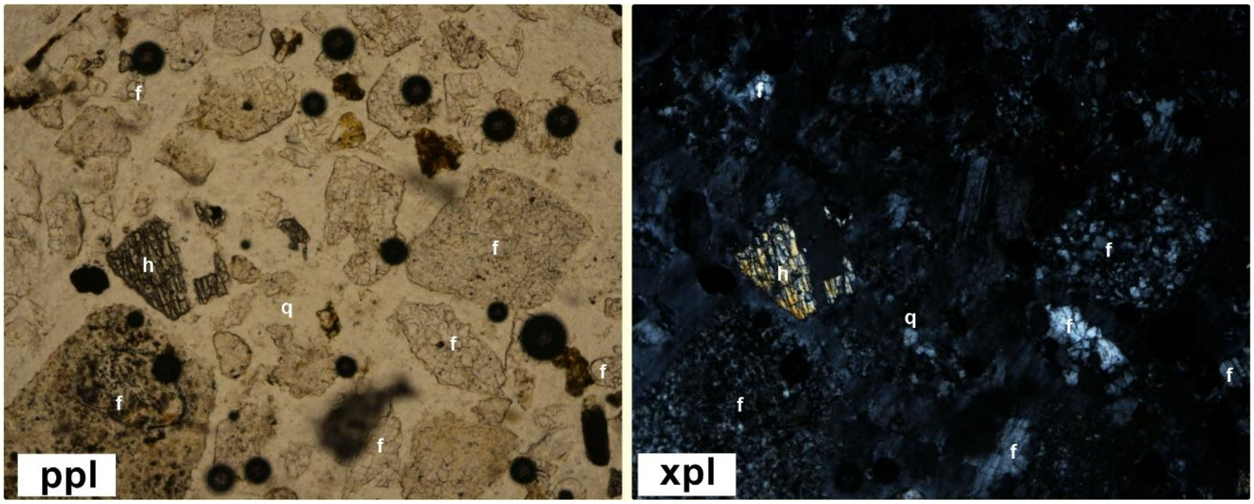

Figure 8. Soil mineral appearance from Qlvp parent material with dominant minerals consisting of hornblende (h), feldspar (f), and quartz (q). Size 100µm

Soil formed from the Qlvb Rock Formation has a variety of criteria for easily weathered mineral content. The process of mineral weathering and rainfall factors is also influenced by the location of the slopes and intensive land use. In sloping areas, the mineral content of easily weathered is still classified in the moderate to good criteria, ranging from 55-80%. The available easily weathered mineral content is hornblende and pyroxene, while in flat areas, it has low criteria with a range of 35% and is dominated by quartz minerals (Figure 9).

The Tmc rock formation (Camba Formation) supplies easily weathered minerals such as hornblende and pyroxene with very weathered conditions. It is mainly dominated by resistant minerals such as quartz and K-feldspar (Figure 10). Soil mineral reserves are in the range of 30-60%. The source of the original rock is a marine sedimentary rock with the dominance of the original mineral in the form of resistant minerals (Mu'min, Imran, & Safruddin, 2020).

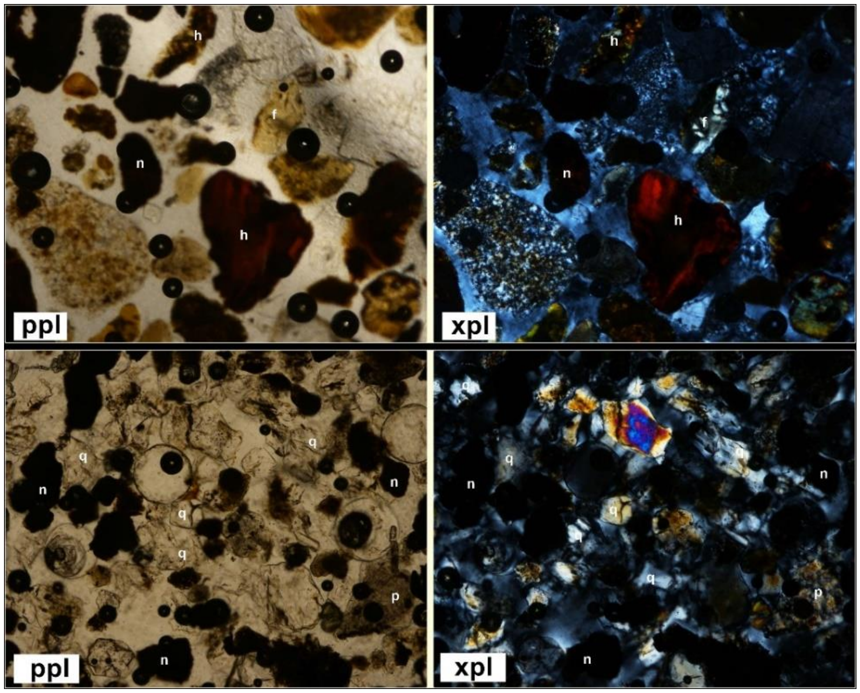

Figure 9. Soil mineral appearance of the parent material Qlvb with the minerals hornblende (h), pyroxene (p), and quartz (q). Size 100µm

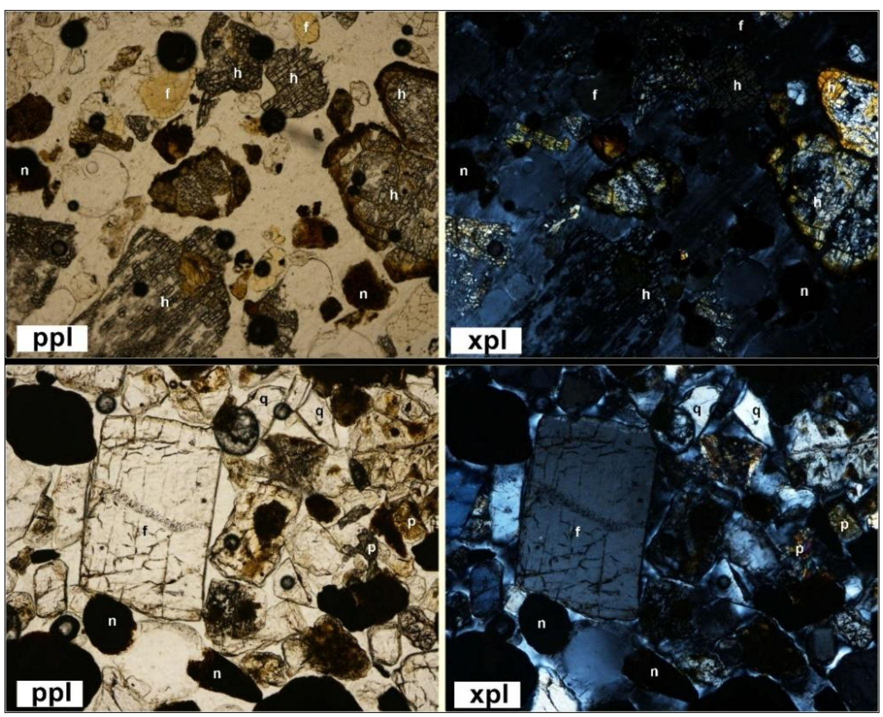

Figure 10. Soil mineral appearance from the parent material Tmc with dominant minerals consisting of hornblende (h), feldspar (f), and quartz (q). Size 100µm

The easily weathered soil minerals contributed by the parent rock of the Tonasa Formation (Tet), are dominated by calcite minerals, while the resistant minerals found are quartz minerals (Figure 11). The calcite mineral has mostly been transformed into nodules. The easily weathered mineral reserves in the soil are in the good range of >70%.

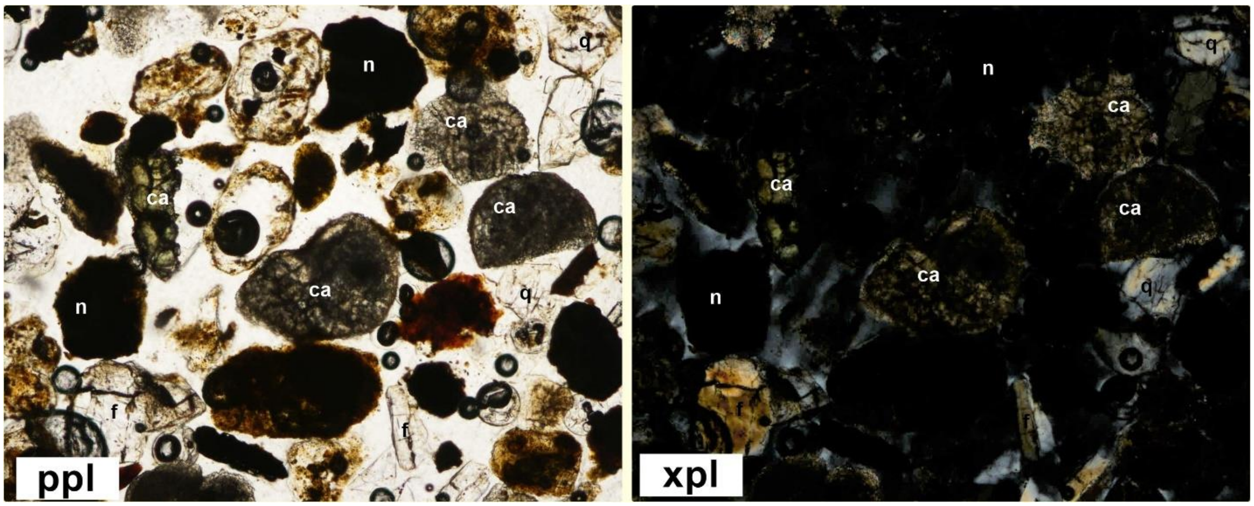

Figure 11. Soil mineral appearance of Tet parent material with dominant minerals consisting of calcite (ca), quartz (q), and nodules (n). Size 100µm

The distribution pattern of soil fertility potential based on soil minerals in the good category is found in the West Bangkala District, the southern part of the Bangkala District, the western part of the Tamalate District, the northern part of the Kelara District, and the southern part of the Rumbia District (Figure 12). Meanwhile, in the low category, there are Bangkala Binamu Districts and parts of Arungkeke Districts. High non-resistant mineral content with high weathering rates caused by intensive land use without good soil management can accelerate weathering and leaching of nutrients contained in minerals (Figure 6-11). The uneven and increasing rainfall pattern in the eastern Jeneponto Regency can increase mineral weathering and high leaching. The decrease in soil carbon content is in line with the decrease in the nutrient content in the soil due to the reduced function of soil colloids. Recommendations for improving soil quality can be made by adding organic matter in the soil and applying cropping rotations between corn plants and horticultural crops in Rumbia District and alternating between paddy fields and corn plants in flat areas with low rainfall, especially in Bangkala and West Bangkala Districts.

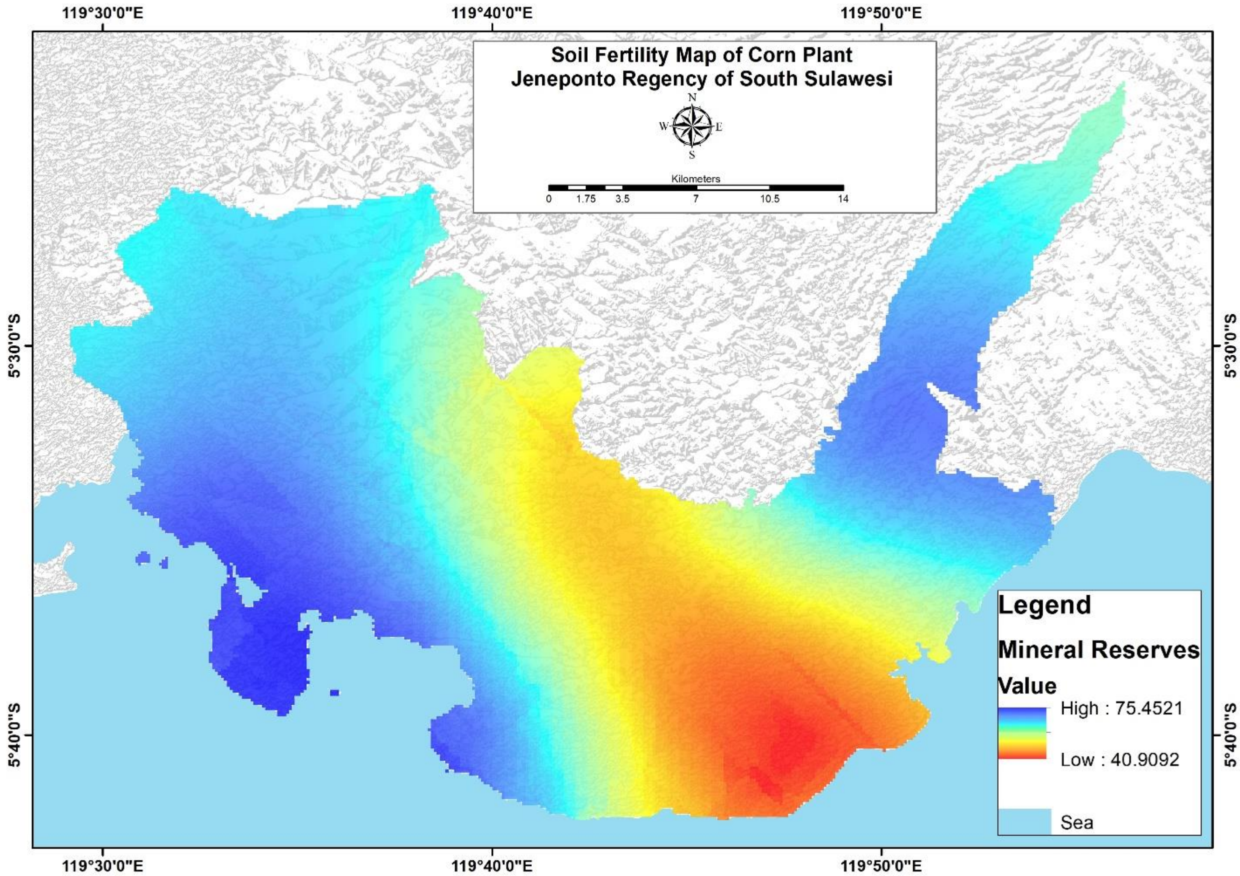

Figure 12. Soil fertility of corn map in Jeneponto Regency

The development of maize in Jeneponto Regency can be expanded to the western part and spread to the northern part to Rumbia District in the southern part, Kelara District, Tarowang, Bontoramba, and Tamalatea. Arungkeke District, as one of the producers of hybrid corn, needs to take management actions to improve soil quality. This district has experienced a decrease in easily weathered mineral content, low soil c-organic content, and soil pH with a slightly acidic criterion. The use of chemical fertilizers will continue to increase and cannot be sustainable. The best management for the development of corn is by adding organic fertilizers (Urrutia, Fuentes, Olaetxea, & Garnica, 2020) and crop rotation so that the nutrient content released by easily weathered soil minerals can be chelated by soil organic matter (Fendji, Kenmogne, Fotsa-Mbogne, & Forster, 2021).

CONCLUSION

The easily weathered nutrient content found in the soil is strongly influenced by the mineral content found in the parent rock. The parent rock found in Jeneponto Regency is dominated by rocks rich in easily weathered minerals, so the Jeneponto Regency is classified as a potential area for developing corn plants. Nutrient reserves of easily weathered minerals are classified as moderate to good, with an average range of 55-75%. The development of corn in Jeneponto Regency can be expanded to the western part and spread to the northern part to Rumbia District in the southern part, Kelara District, Tarowang, Bontoramba, and Tamalatea. Arungkeke District, as one of the producers of hybrid corn, needs to implement management measures to improve soil quality because this sub-district has experienced a decrease in the content of easily weathered minerals and C-organic soil.

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