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RESEARCH PAPER

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Soil fertility analysis for rice production in the lowland areas of Diplahan, Zamboanga Sibugay, Mindanao, Philippines

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Key words: Lowland areas, Nutrient management, Rice production, Soil samples

Abstract

The most important practice that contributes to rice production is nutrient management. However, if the nutrient plant required is insufficient, low production is unavoidable. Thus, this study was carried out to determine the soil fertility status of lowland areas in the municipality of Diplahan. Soil samples from each sampling site were collected in rice farms using a composite random soil sampling moving in a zigzag pattern. A depth of 0- 15cm soil samples were collected from 15 - 30 different places in 1-5 hectares. An air-drying procedure was done before it was carried to the laboratory for final testing. Soil samples were analyzed for pH, organic carbon, organic matter, nitrogen, phosphorous, and potassium following the BSWM (Bureau of Soils and Water Management) procedures. Furthermore, a soil fertility map was outlined through ArcGIS software by plotting local coordinates in Google Map. Results showed that the areas in 10 selected barangays in the municipality have moderate soil acidity, with a pH level that falls below the desirable range of 5.5 - 7.0 but no lower than 4.5. According to the results of the soil organic carbon analysis, all barangays have insufficient SOC. Only four barangays have the optimal soil organic matter content for lowland rice production. The study also revealed that only two (2) barangays receive an adequate amount of nitrogen, while the rest are considered deficient. Phosphorous-rich soils were found in two (2) barangays; the five (5) barangays have a medium content; and the remaining three (3) barangays have a low content. Lastly, no barangay in the municipality obtains an adequate amount of exchangeable potassium ranging from 82-246 ppm. Problem of insufficient nutrient requirements for rice crop production is widespread in the municipality.

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Introduction

The soil is the building block of the agricultural system. Crop production is influenced by soil quality. The soil provides the physical, chemical, and biological processes that allow most terrestrial plant and animal life to thrive. The soil regulates water flow from rainfall and acts as buffer between production activities and the environment by facilitating the cycling and decomposition of organic wastes and nutrients, as well as the degradation of nitrates, pesticides, and other toxic substances (Carating, 2007). The success of maintaining or enhancing soil quality depends on understanding of how the soil responds to agricultural land use (Lima *et al*, 2011). Soil quality concerns are not limited to agricultural scientists, natural resource managers, and policymakers; farmers have a vested interest in soil quality as well (Gregorich, *et al*., 1994; Roming *et al*., 1995).

In the Philippines the demand for soil information today is much greater than it was decades ago (Galanta *et al*, 2007). Numerous constraints in maintaining good soil condition have emerged in the country. Rice monoculture for an instance contributed to the degradation of paddy resource base and consequently resulted to declining soil productivity (Bautista and Javier, 2008). In lowland rice production, nitrogen, phosphorous, and potassium deficiency are the major soil constraints and other than that several lowland areas in the country have been experiencing salinity, alkalinity problem including acid sulfate (Galanta *et al*., 2007). Another study discovered that farmers' perceptions and practices may be a contributing factor to land degradation (Pulido and Bocco, 2014).

In the lowland areas of Diplahan problem on soil fertility evaluation has yet to be addressed. Many farmers were discovered to be unaware of the current state of soil fertility in their areas. Farmers use a lot of synthetic fertilizers to keep the soil fertile and increase productivity. However, applying fertilizer without a fertilizer recommendation may have negative consequences because the nutrients in the soil may exceed the nutrients required. This will actually result in soil fertility depletion, which is one of the major problems in less-favored areas (Scherr, 1999), as well as a high likelihood of nutrient leaching. To achieve passable crop growth and sufficient crop yield, ensuring crops a proper nutrition is necessary. Soil fertility testing is effective in increasing productivity (Darby, 2011) and assessing nutrient balance (Carating, 2007), and is thus regarded as the first step in managing soil fertility (McKenzie, 1998).

This study was conducted in the area due to the insufficient evaluation of soil fertility, which resulted in many local farmers wasting their resources by applying large quantities of fertilizer without fertilizer recommendations. To restore nutrients to their soil, the majority of rice farmers in Diplahan used complete fertilizer or urea. Farmers must conduct soil tests prior to fertilizer application to ensure that the correct type and amount of fertilizer is applied for a profitable yield (Rashid and Rafique,1998; Rashid and Ryan, 2004). Since there was no comprehensive information on the soil fertility status of rice fields in the municipality, the current study sought to determine fertility status of lowland rice fields in Diplahan. Specifically, the obejectives of the study include: 1. To determine the soil fertility status of lowland in both irrigated and non-irrigated rice fields in Diplahan. Specifically, this includes, assessment of soil fertility status, pH, organic carbon, organic matter (OM), nitrogen, phosphorous, and potassium; 2. Delineate a fertility map for rice fields in the área; 3. Provision of a locality-specific fertilizer recommendation based on soil fertility aspects and rice nutrient-need requirements.

Materials and methods

Study site

This study was conducted in the municipality of Diplahan, Zamboanga Sibugay, Philippines (Fig. 1). It is a landlocked municipality in the coastal province of Zamboanga Sibugay. The municipality has a land area of 255.51 square kilometers or 98.65 square miles distributed among 22 villages which constitute 7.08% of Zamboanga Sibugay's total area. The municipality of Diplahan is one of the major rice producers in the province of Zamboanga Sibugay which also covers a wide array of river basin which support the water system of the agriculture areas specifically rice production.

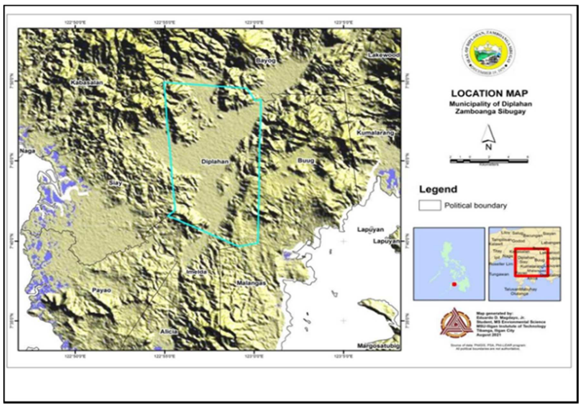

Fig. 1. Sampling site of the study, map of the municipality of Diplahan, Zamboanga Sibugay.

Soil sampling method

Soil samples were collected in rice farms using a composite random soil sampling moving in a zigzag pattern. A depth of 0- 15cm soil samples were collected from 15 - 30 different places in 1-5 hectares. An air-drying procedure was done before it was carried to the laboratory for final testing.

Soil sampling procedure

Soil samples were collected in a uniform area (slope, texture, depth, drainage and crop grown) with a depth of 0 - 15cm (Fig. A) in 15 - 30 different spots in a zigzag manner (Fig. B). The collected soil samples were then placed in a container, and poured into a plastic sheet. The lot was divided into four (Fig. C) quarters. The procedure was repeated until the desired volume of soil (1-2kg) will attain.

GIS mapping

DIVA - GIS was used for mapping by finding the coordinates of localities using Google map, and by checking existing coordinates using overlays of the collection sites and administrative boundary databases.

Results and discussions

Soil fertility analysis results

Soil pH (Potentiomeric Method)

The soil pH is closely linked to the concept of the acidity and alkalinity. Soil pH is an important consideration for farmers because many plant and soil life forms prefer either an acidic or an alkaline condition. In addition, some diseases tend to thrive when the soil is acidic or alkaline, and that pH affects the availability of nutrients in the soil (Carating, 2007). Based on the ideal pH for rice, which is 5.5 to 7.0 (Sangatanan, 1990), the results revealed that none of the 10 barangays tested had the preferable average soil pH (Fig. 1), indicating that the barangays in Diplahan have low potential hydrogen, indicating soil acidity. Calcium, magnesium, and phosphorus become less available as a result of this situation, and many organisms do not thrive in such an acidic condition (Carating, 2007). According to Ilagan *et al.* (2014), values less than 5.5 resulted in a moderately to strongly acidic soil reaction. Acidic rice fields observed may not require liming to correct soil acidity; instead, simple flooding or field submergence may be used (Serchan and Jones, 2009).

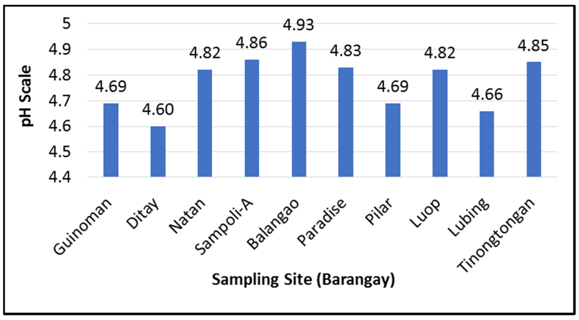

Fig. 2. Average soil pH in ten (10) selected Barangays of Diplahan.

% Organic Carbon (Walkey Black Method)

Soil organic carbon (SOC) storage is the most important function of agricultural soil because it interacts with other functions such as soil fertility, nutrient cycling, temperature, and pH balance (Follet *et al*, 2007; Conant *et al*, 2002). According to the Soil Organic Carbon criteria for rice production, 2 percent, 2.01-4 percent, 4.01-10 percent, 10.01-20 percent, and >20 percent are included for very low, low, medium, high, and very high, respectively (Sigarp *et al.*, 2003). As shown in Fig. 2, none of the ten barangays were able to obtain a sufficient amount of Soil Organic Carbon. Six (6) barangays in Diplahan have a very low SOC of less than 2%, indicating deficiency, while the remaining four (4) barangays have low SOC ranging from 2.01-4%, indicating deficiency as well.The study's findings indicate that the municipality has a problem with Soil Organic Carbon Deficiency. Many management practices have been proposed to improve SOC, including no-tillage management, crop rotation, manure or crop residue addition, biochar, and other amendments (Lal, 2011; Arunrat *et al*, 2020). The SOC also contributes to "soil resilience", which is the ability of soil to recover after a deterioration event such as drought conditions (Hoyle *et al*, 2011).

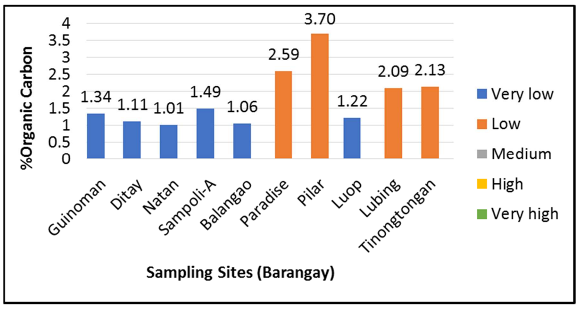

Fig. 3. Average% Organic Carbon (OC) content in ten (10) selected Barangays of Diplahan.

% Organic Matter (By Computation)

Organic matter is one of the compositions of the soils, in addition to minerals, water, and living organisms. Organic matter, despite constituting a minor component of mineral soils, plays an important role in soil productivity and conditioning (Carating, 2007). And it is an important component of a productive soil, particularly as the primary source of nitrogen (Grant, 1965), which is essential for rice growth and grain production (Balck and Bewley, 2000). According to the general guidelines for rice soil fertility ratings, an adequate Organic Matter (OM) percentage for lowland rice is greater than 3% (Ilagan *et al.*, 2014), and results less than 3% are considered deficient and unfavorable.

Based on the study results, only four (4) barangays in Diplahan have a favorable amount of organic matter, namely Paradise, Pilar, Lubing, and Tinongtonan while the rest barangays have low amount of organic matter content, which indicates deficiency (Fig. 2). It is evident in the findings that many barangays did not obtain the desirable amount of organic matter. Many studies suggest that unsuitable management practices are one of the factors contributing to organic matter depletion (Alam *et al* 2014). Farmers in Diplahan have been practicing conventional tillage based on the interview and actual observation. And this activity according to Rhoton's (2000) study, can result in a 10% loss of initial organic matter. Mann's (1986) study found that tillage cultivation depleted 16 to 77 percent of organic matter.

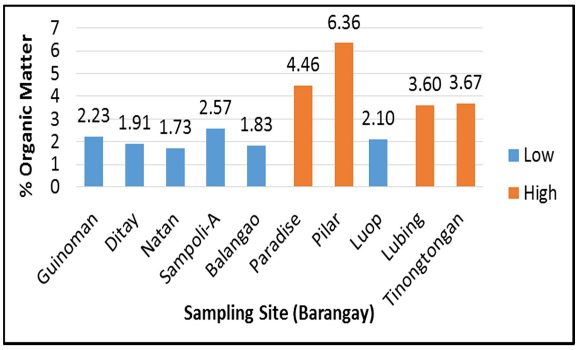

Fig. 4. Average% Organic Matter (OM) content in ten (10) selected Barangays of Diplahan.

Available% Nitrogen (By Computation)

Nitrogen is a mineral nutrient that is essential for plant growth and productivity because it not only increases yield but also improves food quality (Ullah *et al.* 2010; Leghari *et al.* 2016). Plants will not grow optimally if N levels are low.

The benchmark of percent nitrogen for rice production in lowland areas ranges from less than 0.1 percent, 0.1-0.2 percent, 0.21-0.5 percent, 0.51-1.0 percent, and >1.0 percent, indicating very low, low, medium, high, and very high, respectively (Sigarp *et al.*, 2005). The results revealed that only two (2) barangays, Pilar and Paradise, have a reasonable amount of nitrogen content, while the remaining barangays have an insufficient amount of nitrogen content (Fig. 4).

According to other research, nitrogen deficiency is the most common deficiency in rice soils. Early nitrogen deficiency in rice results in yellow to yellowish green leaves as well as stunted and spindly growth. When a deficiency occurs later age, yellowing appears first on older leaves (Galanta *et al*, 2007).

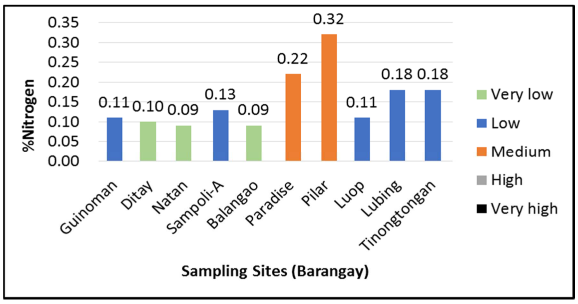

Fig. 5. Average% Nitrogen content in ten (10) selected Barangays of Diplahan.

Available Phosphorous (ppm) (Olsen Method)

Phosphorus is a major plant nutrient that is required for root, flower, and fruit development, as well as the strengthening of rice straws. Phosphorus is required for the energy transfer system. It is a component of RNA and DNA that regulates genetic information (Moorman and Dudal, 1968). It is also required for phytin, which is an important component of seeds (Yoshida, 1981). Categorical level of available P (Olsen P method) for rice ranges with values <5ppm, 5-10ppm, and >10ppm inclusive for low, medium and high available phosphorus, respectively. Fig. 5 shows that only two (2) barangays, Sampoli-A and Balangao, have a sufficient or high amount of available phosphorous. Barangay Ditay, Natan, Paradise, Pilar, and Luop have phosphorous levels in the range of 5-10 ppm, indicating a medium amount of available phosphorous. And the three (3) barangays (Guinoman, Lubing, and Tinongtongan) have a low amount of available phosphorous (less than 5 ppm), indicating a deficiency. Phosphorus deficiency symptoms appear in the lower part of the plant, resulting in fewer leaves, shorter blades, fewer panicles per plant, fewer seeds per panicle, and fewer filled seeds (Carating, 2007).

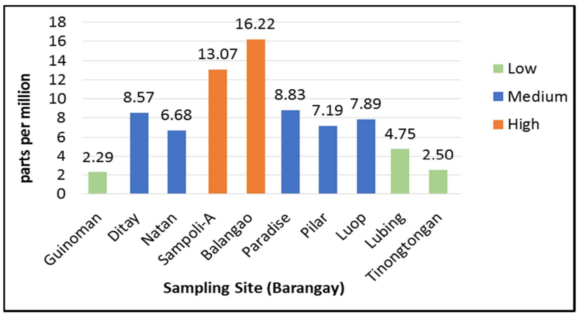

Fig. 6. Average available phosphorous (ppm) in ten (10) selected Barangays of Diplahan.

Exchangeable Potassium K (ppm) (Cold H_2SO_4 Extraction Method)

Potassium, like phosphorus and nitrogen, is an important plant nutrient that must be considered in fertility management. Potassium promotes panicle development and has an effect on grain fill in rice. It also promotes tillering, spikelet fertility, nitrogen and phosphorus uptake, leaf area and longevity, and root elongation and thickness. It also has profound effect in increasing resistance to diseases and insects. By increasing stem strength and producing healthy leaves, plants benefit from increased pest tolerance (Carating, 2007). Based on the optimum potassium of rice were 1.8-2.6%, 1.4- 2.0% and 1.5-2.0% in the tillering to panicle initiation stage, flowering stage and maturity stage respectively (Ilagan *et al*, 2014). Available K (ppm) for rice ranges with values 20-80ppm and 82-246ppm representing low and high available potassium, respectively (William and Smith, 2001). Fig. 6 shows that no barangay in the municipality of Diplahan obtains an adequate amount of exchangeable potassium ranging from 82-246 ppm. It reveals that a lack of exchangeable potassium has been a problem in the municipality for growing rice crops. Potassium deficiency is characterized by chlorosis (yellowing) along the leaf margins followed by scorching and browning of the tips of the older leaves. The symptoms gradually progress inward. The crops also suffer from slow and stunted growth (Carating, 2007).

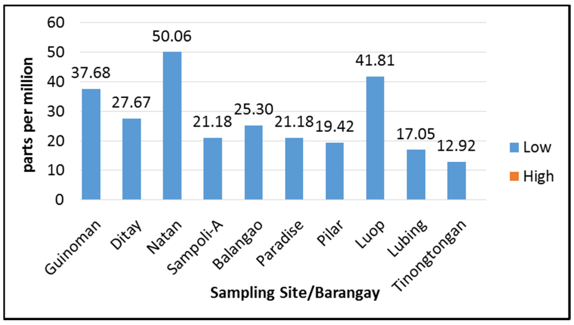

Fig. 7. Average exchangeable potassium in ten (10) selected Barangays of Diplahan.

Soil Fertility Maps in the Municipality of Diplahan, Zamboanga Sibugay

Based on the favourable pH for rice ranges 5.5-7.0, the results revealed that no barangay had a preferable soil pH, as shown in the map (Fig. 7).

As appeared in Fig. 8, the ten barangays have less than 4% soil organic carbon, indicating a deficiency. Only four barangays in Diplahan (Paradise, Pilar, Lubing, and Tinongtonan), as exhibited in the map (Fig. 9), have enough organic matter to exceed 3 percent, while the remaining barangays are considered deficient. According to the map (Fig. 10), only two barangays (Pilar and Paradise), denoted by blue and violet colors, have a medium amount of nitrogen content ranging from 0.21 to 0.5 percent, while the rest fall below the reasonable amount of nitrogen.

It also revealed that, with the exception of Guinoman, Lubing, and Tinontongan, the barangays in Diplahan were phosphorous-rich. Lastly, insufficient potassium content was widespread in the municipality of Diplahan, and as manifested in Fig. 12, no barangay has reached the preferable exchangeable potassium content range of 82-246 ppm.

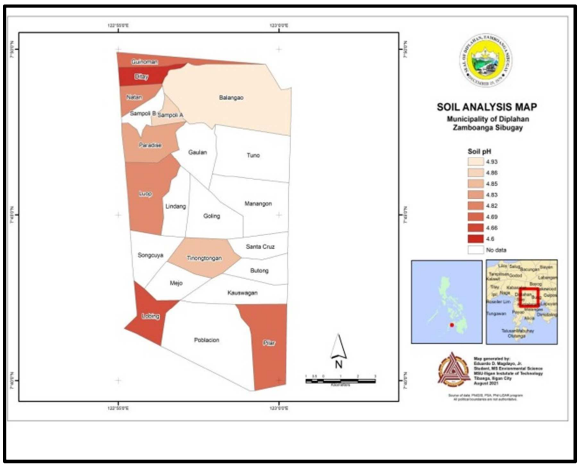

Fig. 8. Soil pH Map.

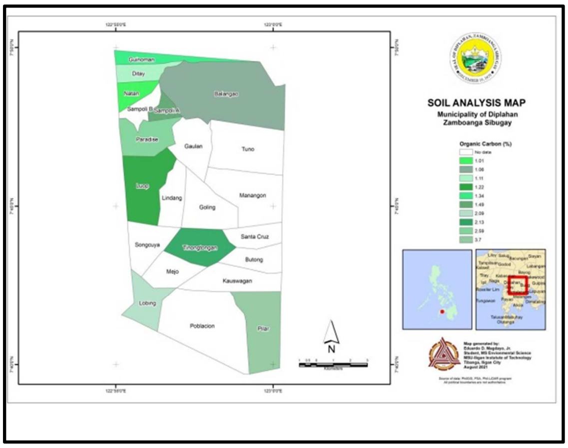

Fig. 9. Soil Organic Carbon Map.

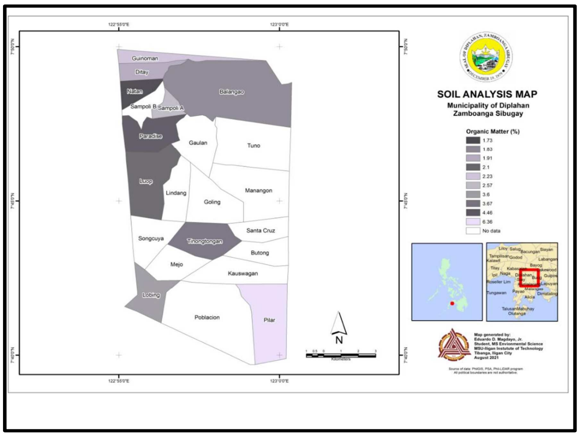

Fig. 10. Soil Organic Matter Map.

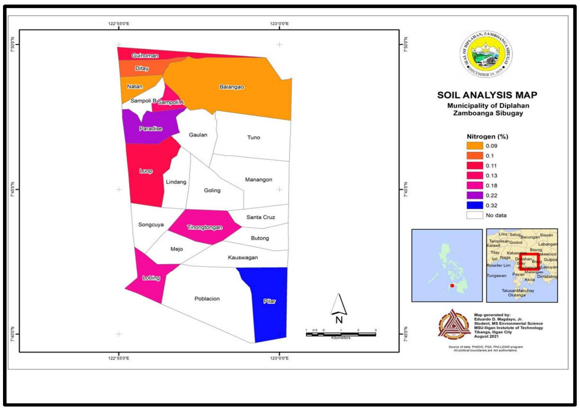

Fig. 11. Soil Nitrogen Map.

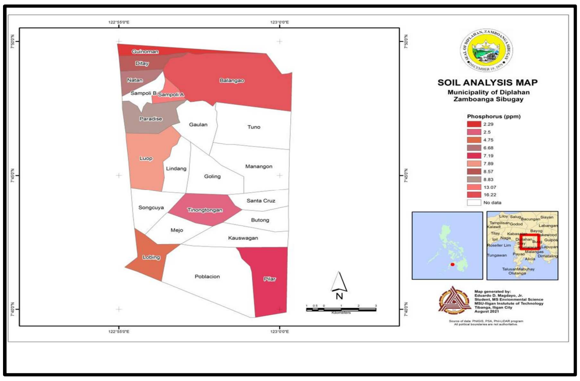

Fig. 12. Soil Phosphorous Map.

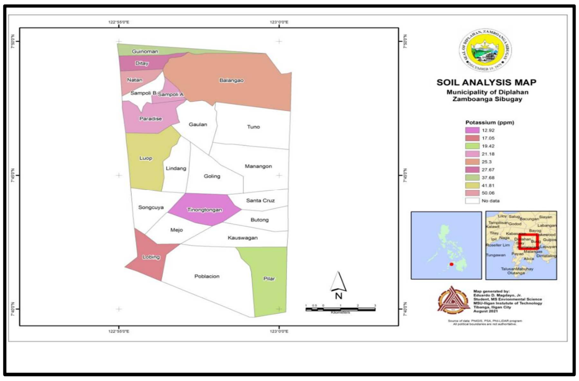

Fig. 13. Soil Potassium Map.

Locality-specific fertilizer recommendation based on soil fertility results

The amount of fertilizers needed by the plants depend on the inherent fertility of the soil. Table 1 shows the fertilizer recommendation for rice following the reference from Regional Soil Laboratory IX analysis. The table gives the local farmers the idea on the amount of fertilizers to apply.

The table presents the recommendation of both rice inbred and rice hybrid varieties. The lower the nutrient content, the higher the amount of the needed fertilizers.

Barangay	Crop	Nutrient Requirement (N-P-K)	Fertilizer Recommendation per Hectare
Guinoman	Rice (Inbred)	100-40-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 5.75 bags complete fertilizer (14-14-14); 21.75kg of Urea (46-0-0); and 33.35kg Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.1 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.1 bags of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	120-40-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 5.75 bags complete fertilizer (14-14-14); 43.5kg of Urea (46-0-0); and 33.35kg Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.35 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.35 bags of Urea (46-0-0) 20-25 days after transplanting.
Ditay	Rice (Inbred)	80-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 21.75kg of Urea (46-0-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 43.50kg of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 43.50kg of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	100-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 43.5kg of Urea (46-0-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.10 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.10 bags of Urea (46-0-0) 20-25 days after transplanting.
Natan	Rice (Inbred)	100-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 43.5kg of Urea (46-0-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.10 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.10 bags of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	120-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 1.35 bags of Urea (46-0-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.35 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.35 bags of Urea (46-0-0) 20-25 days after transplanting.

Barangay	Crop	Nutrient Requirement (N-P-K)	Fertilizer Recommendation per Hectare
Balangao	Rice (Inbred)	100-0-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 2.2 bags of Urea (46-0-0); and 2 bags Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.10 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.10 bags of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	120-0-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 2.65 bags of Urea (46-0-0); and 2 bags Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.35 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.35 bags of Urea (46-0-0) 20-25 days after transplanting.
Sampoli-A	Rice (Inbred)	80-20-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 2.9 bags complete fertilizer (14-14-14); 43.5kg of Urea (46-0-0); and 1.35 bags Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 43.50kg of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 43.50kg of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	100-20-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 2.9 bags complete fertilizer (14-14-14); 1.35kg of Urea (46-0-0); and 1.35 bags Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.10 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.10 bags of Urea (46-0-0) 20-25 days after transplanting.
Paradise	Rice (Inbred)	80-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 21.75kg of Urea (46-0-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 43.50kg of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 43.50kg of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	100-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 43.5kg of Urea (46-0-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.10 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.10 bags of Urea (46-0-0) 20-25 days after transplanting.
Pilar	Rice (Inbred)	0-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 3.35 bags Solophos (0-18-0) and 2 bags Muriate of potash (0-0-60) after last harrowing.
	Rice (Hybrid)	0-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 3.35 bags Solophos (0-18-0) and 2 bags Muriate of potash (0-0-60) after last harrowing.
			After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 21.75kg of Urea (46-0-0); and 1 bag Muriate of potash (0-0-

Barangay	Crop	Nutrient Requirement (N-P-K)	Fertilizer Recommendation per Hectare
Luop	Rice (Inbred)	80-30-60	60) after last harrowing. For the 2nd application: Topdress with 43.50kg of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 43.50kg of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	100-30-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 43.5kg of Urea (46-0-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.10 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.10 bags of Urea (46-0-0) 20-25 days after transplanting
Lubing	Rice (Inbred)	60-40-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 4.3 bags complete fertilizer (14-14-14); 1.15 bags Solophos (0-18-0); and 1 bag Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 32.65kg of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 32.65kg of Urea (46-0-0) 20-25 days after transplanting.
	Rice (Hybrid)	80-40-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 5.75 bags complete fertilizer (14-14-14); and 33.35kg Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 43.50kg of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 43.50kg of Urea (46-0-0) 20-25 days after transplanting
Tinongtongan	Rice (Inbred)	80-40-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 5.75 bags complete fertilizer (14-14-14); and 33.35kg Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 43.50kg of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 43.50kg of Urea (46-0-0) 20-25 days after transplanting
	Rice (Hybrid)	100-40-60	After 2nd harrowing, incorporate 10-20 bags organic fertilizer (Basal) For the 1st application: Apply 5.75 bags complete fertilizer (14-14-14); 21.75kg of Urea (46-0-0); and 33.35kg Muriate of potash (0-0-60) after last harrowing. For the 2nd application: Topdress with 1.1 bags of Urea (46-0-0) 10-14 days after transplanting. For the 3rd application: Topdress with 1.1 bags of Urea (46-0-0) 20-25 days after transplanting.

Conclusion

The most important practice that contributes to rice production is nutrient management. Crop yield, in general, is determined by the soil inherent fertility. However, if the nutrient plant required is insufficient, low production is unavoidable. This study was carried out to determine the soil fertility status of lowland areas in the municipality of Diplahan. The findings revealed that the areas in 10 selected barangays in the said municipality have moderate soil acidity, with a pH level that falls below the desirable range of 5.5 - 7.0 but no lower than 4.5. According to the results of the soil organic carbon analysis, all barangays have insufficient SOC. Only four barangays (Paradise, Pilar, Lubing, and Tinongtongan) have the optimal soil organic matter content for lowland rice production. The study also revealed that only two (2) barangays (Paradise and Pilar) receive an adequate amount of nitrogen, while the rest are considered deficient. Phosphorous-rich soils were found in two (2) barangays (Sampoli-A and Balangao); the remaining five (5) barangays (Ditay, Natan, Paradise, Pilar, and Luop) have a medium content; and the remaining three (3) barangays (Guinoman, Lubing, and Tinongtongan) have a low content. Lastly, no barangay in the municipality obtains an adequate amount of exchangeable potassium ranging from 82-246 ppm, based on the findings for exchangeable potassium.

According to the findings of the study, the problem of insufficient nutrient requirements for rice crop production is widespread in the municipality. Farmers must become aware of and concerned about this situation in order to avoid inappropriate soil fertility management practices such as applying an insufficient amount of fertilizer to restore soil fertility. Many studies have found that intensive use of inorganic and agrochemical fertilizers reduces soil health and fertility (Souri, 2016; Ge *et al.*, 2018). Continuous cropping without replenishment of soil nutrients depletes natural soil fertility. Therefore, the concerned agencies should take these pressing issues into account when providing extension services for proper soil management. It should be addressed as soon as possible because poor soil nutrient content can have a significant impact on high apparent yield losses.

Recommendations

As expected, all of the soil fertility variables had a significant influence on rice output, signifying their importance in increasing farm productivity.

Based on the findings and conclusions of the study the municipality of Diplahan has been dealing with soil fertility declination resulted to a minimal rice production, thereby the following recommendations are made: Calcium carbonate, $CaCO_3$ (agricultural lime) applications for soils with pH less than 5.5. Farmers can also use flooding for 3-4 weeks to soak the field as a simple and relatively inexpensive way to amend the pH of the soil (Ilagan *et al.*, 2014). Regular soil test should be conducted by the National Government Agencies (i.e. DA, Municipal Agriculture Office, NIA, Phil. Rice, etc.) to monitor the soil fertility level of rice plantations, specifically nitrogen, phosphorus, and potassium levels. Fertilizer should be applied in accordance with rice-specific recommendations for optimum yield.

Aside from the previously mentioned recommendations, the importance of integrated soil fertility management, which includes a combination of organic and mineral fertilizers, crop rotations, animal and green manure applications should be considered and reinforced. Through extension services, the Department of Agriculture develops repetitive learning approaches that encourage the integration of local knowledge with scientific knowledge. Farmers' local knowledge provides the site-specific context local conditions required to adapt new scientific knowledge to farmers' farming socioeconomic conditions, whereas scientific research provides great insight into soil biophysical processes that could be influencing soil fertility. Efforts to increase Integrated Soil Fertility Management (ISFM) adoption will necessitate the use of participatory learning approaches that encourage collective learning and information sharing among targeted adopters and researchers.

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