

# SOIL FERTILITY ASSESSMENT AND NUTRIENT MANAGEMENT FOR OPTIMIZING RICE PRODUCTIVITY IN IRRIGATED LOWLAND AREAS OF NORTHERN MINDANAO

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## ABSTRACT

Food security remains a challenge as the global population nears 9.4 billion by 2050, demanding improved agricultural productivity. Changing farming practices, high-yielding varieties, and climate change necessitate updated soil fertility assessments and nutrient recommendations. This study evaluated the soil fertility of irrigated lowland rice areas in Northern Mindanao using a Randomized Complete Block Design (RCBD) with three replications and the inbred rice variety NSIC 222. Treatments included increasing rates of nitrogen (N), phosphorus (P<sub>2</sub>O<sub>5</sub>), and potassium (K<sub>2</sub>O). Results showed soils were strongly to moderately acidic with varying organic matter, highest in Bukidnon. A balanced fertilizer application of 60 kg/ha N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O consistently achieved the highest yields (5.0–5.90 tons/ha).

**Keywords:** *Soil Fertility, Rice Productivity, Nutrient Management*

## 1. INTRODUCTION

Food security is a critical global issue, particularly as the population is projected to grow from 7.0 billion to 9.4 billion by 2050. Meeting this demand requires not only increased agricultural productivity but also the sustainable use of land, water, and energy resources. In the Philippines, rice is a staple crop, accounting for 26.2% of the agricultural sector's value. The country achieved a record rice harvest of 19.28 million tons in 2017, a 9.6% increase from the previous year, largely driven by favorable weather conditions. However, sustaining this growth requires continuous improvement in rice productivity. To meet the challenges posed by changing farming practices, the adoption of high-yielding rice varieties, and the impacts of climate change, updated soil fertility assessments and nutrient recommendations are necessary. Soil testing plays a crucial role in determining nutrient imbalances and providing accurate fertilizer recommendations to optimize crop yields. The challenge, however, lies in aligning soil test results with crop responses to nutrient applications. By understanding the relationship between nutrient availability in the soil and appropriate fertilization practices, we can develop strategies to enhance rice productivity and profitability while ensuring long-term sustainability in the face of increasing global demand.

## OBJECTIVES

The study aims to assess the soil fertility status in irrigated lowland rice areas in Northern Mindanao and to provide updated nutrient recommendations for irrigated lowland rice production in Northern Mindanao.

## 2. REVIEW OF RELATED LITERATURE

**Soil Fertility.** Soil fertility is crucial for maintaining soil productivity, which is influenced by the soil's nutrient status. While correcting nutrient problems often yields impressive results, the fundamentals of fertility management are not always well understood, leading to improper fertilizer use. The paddy soil-rice system has an efficient nutrient-replenishing mechanism, as demonstrated by some Asian fields where rice has been grown for hundreds of years without fertilizer, yet yields of 1.6 to 2 t/ha were sustained (Kyuma 1996). Long-term experiments by IRRI show that rice initially responds only to nitrogen, but after 8-10 years, responses to phosphorus (P) and potassium (K) are observed (De Datta 1988, Cassman et al. 1995). As crop yields increase, other soil nutrients are depleted (Descalsota et al. 2000), and nutrient imbalances can reduce the effectiveness of fertilizer applications.

## 3. METHODOLOGY

Soil samples were collected from representative rice-growing areas to assess the fertility of farmers' fields. On-farm trials were conducted, with treatments consisting of increasing rates of N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O, as shown in Tables 1. The trials were laid out in Randomized Complete Block Design (RCBD) with three replications. An inbred rice variety (NSIC 222) was used in the study. Data gathered includes pH, % organic matter, extractable phosphorus (ppm), exchangeable potassium (ppm), yield and Return on investment (ROI). Data were gathered from 10 representative samples and analyzed using Analysis of Variance (ANOVA) in a randomized complete block design (RCBD). Means were compared using the Least Significant Difference (LSD) test to determine statistical significance.

**Table 1.** Treatments used in the on-farm trial

TREATMENT	N (kg ha <sup>-1</sup> )	P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	K <sub>2</sub> O (kg ha <sup>-1</sup> )
1	0	120	120
2	60	120	120
3	120	120	120
4	120	0	120
5	120	60	120
6	120	120	0
7	120	120	60

#### 4. PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

Presented in this chapter are the results of the ANOVA as well as the interpretation and analysis of the respective results. Tables and figures were used to illustrate the findings of this study, and the discussion and interpretation of tabular data were made for easy understanding

**Nutrient Status of Irrigated Rice Areas in the Provinces of Northern Mindanao.** The nutrient status of Northern Mindanao's irrigated lowland areas, as shown in Table 2, reveals that soil pH ranges from strongly acidic to moderately acidic. Organic matter content was highest in Bukidnon but generally low across the region. Extractable phosphorus was very high (above 15 ppm), and exchangeable potassium levels ranged from 112.73 to 192 ppm, classified as medium to very high. Lanao del Norte had the lowest exchangeable K, while Camiguin had the highest. Overall, phosphorus and potassium levels in Northern Mindanao are sufficient for rice production.

**Table 2.** Nutrient status of irrigated rice areas in the provinces

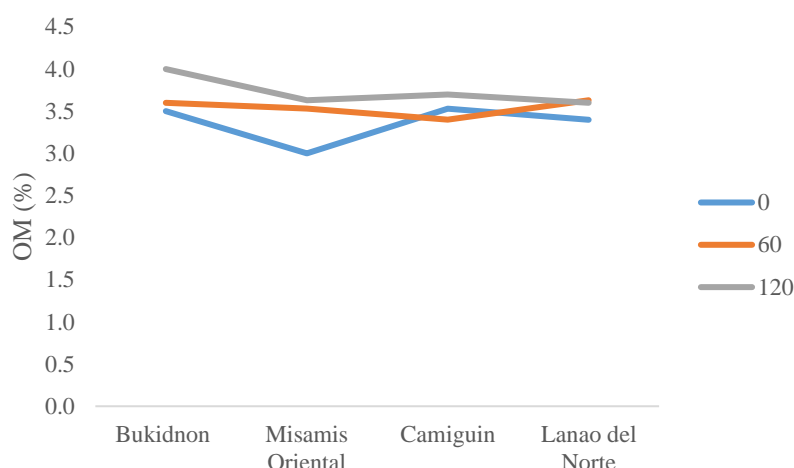
Province	pH	Organic Matter (%)	P (ppm)	K(ppm)
Bukidnon	5.71	3.96	26.10	167.64
Misamis Oriental	5.73	3.67	23.46	144.31
Misamis Occidental	5.42	1.89	20.71	139.49
Lanao del Norte	5.78	1.76	30.21	112.73
Camiguin	5.81	1.89	45.00	192.00

**Initial Soil Analysis.** Initial soil analysis is presented in Table 3. The soil pH is strongly to moderately acidic. Organic matter content (%) is low to high and with extractable P (ppm) which is moderately high to very high and high exchangeable K (ppm).

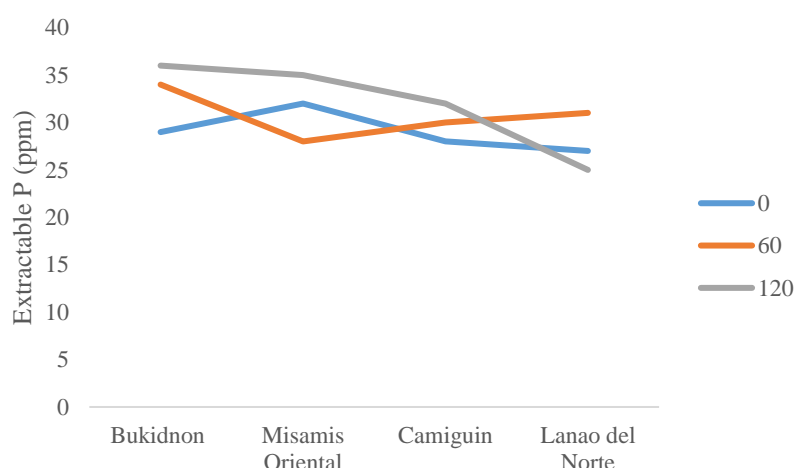
**Table 3.** Initial soil chemical properties

Site	pH	%OM	P(ppm)	K(ppm)
Bukidnon	5.40	2.79	13	100
Misamis Oriental	5.48	4.20	17	134
Camiguin	5.93	1.20	19	197
Lanao del Norte	5.59	1.40	76	219

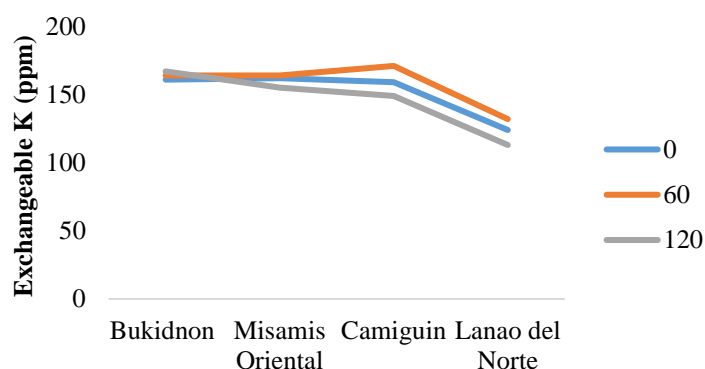
**Postharvest Soil Analysis.** Organic matter content (%) for the different provinces at increasing N rates is presented in Figure 1. Increasing rates of N also increases the %OM of the soil with additions of 60 to 120 kg N/ha. The highest % OM was observed in the addition of 120 kg N/ha and the lowest were in the no application of N in the four provinces' trials. The extractable P (ppm) as influenced by increasing rates of P is depicted in Figure 2. Increasing P applications also increases the available P. Highest available P was observed in the 120 kg P<sub>2</sub>O<sub>5</sub>/ha application with 36, 35, 32, and 31 ppm for Bukidnon, Misamis Oriental, Camiguin, and Lanao del Norte, respectively. The lowest was observed in no application of P in all provinces. Furthermore, exchangeable K (ppm) as influenced by increasing rates of K is shown in Figure 3. Increasing rates of K applied also increase the K available. The highest available K was observed in the addition of 120 kg K<sub>2</sub>O/ha and the lowest in no K fertilization in all provinces. Available K ranges from 113 to 171 ppm in all provinces.



**Figure 1.** Organic matter (%) as influenced by increasing rates of nitrogen



**Figure 2.** Extractable phosphorus (ppm) as influenced by increasing rates of phosphorus Exchangeable Potassium (ppm)



**Figure 3.** Exchangeable potassium (ppm) as influenced by increasing rates of potassium

**Yield (tons/ha).** Yield data presented in Table 4 shows that nitrogen (N) application at 60 kg/ha resulted in the highest yields, while no fertilizer application yielded the lowest. This aligns with the findings of Wood et al. (2021), which suggest that increasing N application enhances rice yield by promoting greater nitrogen uptake. A similar trend was observed for phosphorus (P) and potassium (K). Phosphorus application at 60 kg/ha resulted in the highest yields of 5.0, 5.89, 5.27, and 5.60 t/ha for Bukidnon, Misamis Oriental, Camiguin, and Lanao del Norte, respectively. Phosphorus is crucial for energy transfer as part of Adenosine Diphosphate (ADP) and energy storage through Adenosine Triphosphate (ATP). These processes are essential for flower formation and grain ripening, emphasizing phosphorus's importance in rice development (Paiman et al., 2021). Similarly, potassium application at 60 kg/ha resulted in yields of 5.06, 5.27, 5.27, and 5.90 t/ha for the same provinces. Potassium plays a vital role in metabolic processes, including photosynthesis and respiration. It regulates ion balance within cells, supporting metabolic functions like carbohydrate metabolism and nutrient translocation, which are critical for optimal crop growth.

**Table 4.** Yield (tons/ha) in four provinces as influenced by increasing rates of nitrogen, phosphorus and potassium

Rates (kg N/ha)	Bukidnon	Misamis Oriental	Camiguin	Lanao del Norte
0	4.59b	4.49c	4.45c	5.20b
60	5.03a	5.30a	5.20a	6.10a
120	4.93a	4.97b	5.03b	5.70a
% CV	2.74	3.72	2.40	2.16
F test	**	**	**	**
Rates (kg P <sub>2</sub> O <sub>5</sub> /ha)				
0	4.81b	5.20b	4.47c	5.50
60	5.00a	5.89a	5.27a	5.60
120	4.82b	4.21c	4.77b	5.50
% CV	1.16	1.13	1.19	1.21
F test	**	**	**	ns
Rates (kg K <sub>2</sub> O/ha)				
0	4.82b	4.98b	4.47b	5.50
60	5.06a	5.27a	5.27a	5.90
120	5.00b	5.00b	5.07a	5.60
% CV	1.32	1.23	3.10	2.5
F test	**	**	**	ns

\*- significant

\*\*- highly significant

ns-not significant

## 5. CONCLUSION

The nutrient status of irrigated lowland rice areas in Northern Mindanao reveals that soil pH across the region is strongly to moderately acidic, which can limit nutrient availability and reduce rice productivity. Organic matter content is generally low to high, with Bukidnon showing the highest levels. Postharvest analysis indicates that increasing nitrogen (N) rates, particularly at 60 to 120 kg N/ha, significantly improves soil organic matter, with the highest values observed at 120 kg N/ha. Extractable phosphorus (P) levels are moderately high to very high, and increasing P application rates up to 120 kg P<sub>2</sub>O<sub>5</sub>/ha further increases available P, with Bukidnon recording the highest postharvest P levels. Exchangeable potassium (K) levels are medium to very high across the region, with Lanao del Norte having the lowest and Camiguin the highest. Increasing K rates up to 120 kg K<sub>2</sub>O/ha resulted in higher available K, ranging from 113 to 171 ppm across all provinces. Rice yield data suggest that fertilizer application at 60 kg/ha for N, P, and K consistently produced the highest yields compared to no fertilizer application. Specifically, phosphorus application at 60 kg P<sub>2</sub>O<sub>5</sub>/ha resulted in yields ranging from 5.0 to 5.89 tons/ha, while potassium application at 60 kg K<sub>2</sub>O/ha produced yields between 5.06 and 5.90 tons/.

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