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Assessment of Soil Physico-Chemical Properties of Selected Rice and Corn Production Areas as Influenced by Farmers' Management Practices in Barangay Sugod, Marawi City, Lanao del Sur

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***ABSTRACT**:- This study assessed the soil physico-chemical characteristics and farmers' management practices in selected rice and corn farm sites in Barangay Sugod, Marawi City, Lanao del Sur. A descriptive field survey and soil assessment approach was used. Data were gathered from 25 farmer-respondents using a structured questionnaire, while soil data were obtained through a RS485-Based 8-in-1 Multi-Parameter Soil Sensor and laboratory soil analysis. Five soil point samples were collected from one selected rice farm site, and three soil point samples were collected from one selected corn farm site. Results showed that most respondents practiced crop-based farming, monocropping, conventional tillage, and chemical fertilizer application. However, soil testing, organic material use, and soil conservation practices were limited. Laboratory results indicated that the rice soil was slightly acidic, with low nitrogen and phosphorus but mostly high potassium. The corn soil was acidic to slightly acidic, with medium nitrogen and potassium but low phosphorus. The study concludes that the selected sites have fertility concerns, particularly low phosphorus, and need regular soil testing, site-specific nutrient management, organic matter improvement, conservation practices, and stronger technical assistance.*

***Keywords** - farm management practices, rice-corn production, soil fertility, soil physico-chemical properties, sustainable agriculture*

I. INTRODUCTION

Soil is a fundamental agricultural resource because it supports plant growth, stores nutrients, regulates water, and influences crop productivity. Its condition is commonly described through physico-chemical indicators such as texture, pH, electrical conductivity, moisture, organic matter, and nutrient availability. These indicators are important because they affect nutrient uptake, fertilizer efficiency, water movement, and long-term soil fertility. Recent literature emphasizes that maintaining soil health is necessary for sustainable agriculture, food security, and climate resilience [1-3].

Farmers' management practices also influence soil condition. Tillage, fertilizer application, use of organic materials, irrigation, pest management, and soil conservation practices can either improve or degrade soil quality over time. Integrated and sustainable practices are therefore needed to improve soil productivity and farm resilience, especially in crop-based communities that depend on land resources for livelihood [4-6].

Rice and corn are important crops in Barangay Sugod, Marawi City, Lanao del Sur. Their production depends on adequate soil fertility, water availability, and appropriate nutrient management. However, many farmers still make farm decisions based on experience, available inputs, and immediate production needs rather than soil test results. Soil testing and field-based soil sensing can help guide fertilizer decisions, although rapid sensor readings should be interpreted together with laboratory results [7-9].

This study assessed the soil physico-chemical properties of selected rice and corn production areas as influenced by farmers' management practices in Barangay Sugod. Specifically, it described the farm profile, land and soil characteristics, cropping systems, management practices, resources, challenges, support needs, and measured soil condition of selected sites. The study is relevant to rice and corn nutrient management [10-12], Philippine soil management and farmer knowledge systems [13,14], and the Sustainable Development Goals, particularly SDG 2, SDG 12, SDG 13, and SDG 15 [19].

II. MATERIALS AND METHODS

2.1 Research design and locale

The study used a descriptive field survey approach combined with soil assessment. This design was appropriate because the study intended to describe existing soil conditions in selected farm sites and document the current management practices of farmer-respondents. The study was conducted in Barangay Sugod, Marawi City, Lanao del Sur, where rice and corn farming activities are present.

The survey questionnaire was adapted and modified from the Cornell Soil Health Management Planning Framework, particularly its emphasis on farm background, land base, soil type, cropping system, current and past soil management, producer goals, opportunities, and limitations as part of soil health assessment and planning [20].

2.2 Respondents and sampling procedure

The respondents were 25 farmers and farm managers in Barangay Sugod. They were selected purposively based on active involvement in farming, accessibility during data gathering, and willingness to participate. The respondents provided information on farm background, land base, soil characteristics, cropping system, soil and farm management practices, resources, opportunities, challenges, and support needs.

For soil assessment, one rice farm site and one corn farm site were selected based on accessibility, availability of the area, and permission from the farmer or farm manager. Five soil point samples were collected from different points within the selected rice site, while three soil point samples were collected from different points within the selected corn site. These were treated as point samples within selected farm sites and not as independent samples from several farms. Therefore, the results were interpreted as descriptive and site-specific.

2.3 Instruments and soil sampling

Data were collected using a structured survey questionnaire, a RS485-Based 8-in-1 Multi-Parameter Soil Sensor, and laboratory soil analysis. The questionnaire contained closed-ended, multiple-response, and open-ended items on farm information, soil characteristics, cropping system, fertilizer use, organic material application, pest and disease management, irrigation, erosion, technical assistance, input access, market issues, and support needs.

Field-based readings were taken using the soil sensor to obtain immediate measurements of selected indicators such as soil moisture, temperature, pH, electrical conductivity, and nutrient-related readings depending on device capability. Soil samples were collected at approximately 0-20 cm depth after removing surface litter, stones, and visible plant residues. Each sample was placed in a separate labeled bag and submitted to the Integrated Soils and Plant Tissue Laboratory, College of Agriculture, Mindanao State University, for laboratory analysis.

2.4 Data analysis

Survey responses were summarized using frequency counts, percentages, and ranking. Multiple-response items were analyzed by tallying how many respondents selected each option. Open-ended responses were grouped according to common replies. Soil probe results were presented using actual and consolidated values. Laboratory results were interpreted based on the soil test outputs and the interpretation guide provided by the testing laboratory.

The formulas used in the descriptive analysis were:

$$\text{Percentage (\%)} = (f / N) \times 100 \quad (1)$$

$$\text{Mean} = (\text{sum } x_i) / n \quad (2)$$

The study used descriptive comparison only. Since the soil samples were collected from selected sites and not from multiple independent rice and corn farms, no inferential statistical comparison was made. The relationship between soil properties and management practices was interpreted as an observable association rather than a direct cause-and-effect relationship.

2.5 Ethical considerations

Participation was voluntary, and the purpose of the study was explained to the respondents. They were assured that responses would be kept confidential and used only for research purposes. Permission was also secured from the farmers or farm managers before soil sampling and field sensor readings were conducted.

III. RESULTS AND DISCUSSION

3.1 Farm profile and reported land-based characteristics

Table 1. Farm profile of respondents according to type of farming system

Type of farming system	Frequency	Percentage
Crop only	17	68%
Livestock only	0	0%
Mixed farming	8	32%
Total	25	100%

Table 1 shows that most respondents were engaged in crop farming only. Seventeen respondents, or 68%, practiced crop-only farming, while 8 respondents, or 32%, practiced mixed farming. No respondent reported livestock-only farming. This indicates that crop production is the dominant livelihood activity among the respondents; therefore, soil quality is directly related to farm productivity and income. Soil health is closely linked with crop growth, nutrient availability, water movement, and long-term agricultural sustainability [2,3].

Table 2. Reported land-base and soil characteristics of respondents

Indicator	Category	Frequency	Percentage
Main soil type	Clay	5	20%
	Loam	12	48%
	Sandy	2	8%
	Mixed	5	20%
	Not sure	1	4%
Soil erosion problem	Yes	15	60%
	No	10	40%
Perceived soil fertility	High	2	8%
	Moderate	18	72%
	Low	5	20%
Previous soil testing	Yes	3	12%
	No	22	88%

The most commonly reported soil type was loam, identified by 12 respondents or 48%. Clay and mixed soil were each reported by 5 respondents or 20%, while sandy soil was reported by 2 respondents or 8%. Although loam is generally favorable for crop production, perceived soil type alone is not enough to determine soil productivity because fertility also depends on pH, nutrient availability, organic matter, soil structure, and management history [1,15].

Soil erosion was reported by 15 respondents or 60%, showing an important land management concern. Erosion can remove nutrient-rich topsoil, reduce organic matter, and weaken long-term productivity. Only 3 respondents or 12% had previously conducted soil testing, while 22 respondents or 88% had not. This indicates that most farmers likely rely on experience rather than measured soil fertility information, making regular soil testing important for improving nutrient decisions [7,9].

3.2 Cropping system and farm management practices

Table 3. Cropping system and farm management practices of respondents

Indicator	Category	Frequency	Percentage
Cropping system	Monocropping	16	64%
	Crop rotation	3	12%
	Intercropping	6	24%
	Total	25	100%
Land preparation	Conventional tillage	23	92%
	Reduced tillage	2	8%
	No-till	0	0%
	Total	25	100%
Use of organic materials	Compost	1	4%
	Plant residue	2	8%
	None	22	88%
	Total	25	100%
Type of fertilizer used	Chemical fertilizer only	16	64%
	Both chemical and organic fertilizer	9	36%

	Total	25	100%
Soil conservation practices	Mulching	1	4%
	Cover crop	1	4%
	Fallow period	9	36%
	None	14	56%
	Total	25	100%

Table 3 shows that monocropping was the most common cropping system, practiced by 16 respondents or 64%. Intercropping was practiced by 6 respondents or 24%, while crop rotation was practiced by only 3 respondents or 12%. Limited crop diversification may reduce opportunities to improve soil cover, nutrient cycling, and pest regulation, although the result should be interpreted only as a management pattern and not as direct proof of soil degradation.

Conventional tillage was used by 23 respondents or 92%, while only 2 respondents or 8% practiced reduced tillage. No respondent reported no-till farming. Repeated soil disturbance can affect soil structure, moisture movement, root development, and erosion risk, especially when not supported by conservation practices [6,16]. Organic material use was also very limited. Only 1 respondent or 4% used compost, 2 respondents or 8% used plant residues, and 22 respondents or 88% used no organic material. This may limit long-term organic matter improvement and nutrient cycling [17,18].

Chemical fertilizer was the main nutrient source, with 16 respondents or 64% relying on chemical fertilizer only and 9 respondents or 36% using both chemical and organic fertilizer. This finding is important when related to the laboratory results, which showed low phosphorus in both farm sites and low nitrogen in the rice site. Since most farmers had no previous soil testing, fertilizer application may not be fully guided by actual soil nutrient requirements.

Table 4. Pest and disease management practices of respondents

Pest and disease management practice	Frequency	Percentage
Use of chemical pesticides	24	96%
Use of fertilizers to strengthen plants	17	68%
Use of resistant or improved seeds	8	32%
Manual removal of pests	3	12%
Crop rotation	2	8%
Burning or cleaning infected plants	1	4%

The most common pest and disease management practice was chemical pesticide use, reported by 24 respondents or 96%. This indicates high dependence on chemical pest control. Only a small number of respondents practiced manual removal, crop rotation, or sanitation through burning or cleaning infected plants. The result suggests the need for farmer training on integrated pest management because soil health, crop resilience, and productivity are influenced by several related practices, including nutrient management, cropping system, pest management, and conservation [4,5].

3.3 Farm resources, challenges, and support needs

Table 5. Farm resources and opportunities of respondents

Indicator	Category	Frequency	Percentage
Farm equipment access	Own	19	76%
	Rent	4	16%
	Borrow	2	8%
Irrigation access	Yes	17	68%
	No	8	32%
Technical assistance	Yes	1	4%
	No	24	96%
Nearby organic inputs available	Yes	3	12%
	No	22	88%
Shared/rental equipment access	Yes	6	24%
	No	19	76%
Skilled labor available	Yes	1	4%
	No	24	96%
Expansion opportunities	Yes	9	36%
	No	16	64%

Most respondents owned farm equipment and 68% reported irrigation access. However, technical assistance was extremely limited, with only 1 respondent or 4% reporting that they had received such support. Nearby organic inputs were also limited, reported by only 3 respondents or 12%. These findings are important because technical guidance and access to inputs influence farmers' ability to adopt soil testing, nutrient management, organic material use, and conservation practices [13,14].

Table 6. Challenges affecting farm production

Challenge	Frequency	Percentage
Financial constraints	25	100%
Market access issues or low prices	23	92%
Labor shortage or lack of skilled workers	17	68%
Soil erosion or highly erodible land	12	48%
Limited access to inputs	12	48%
Poor soil condition	9	36%
Climate or weather issues	7	28%
Limited technical knowledge or training	6	24%
Limited access to equipment or machinery	3	12%
Small farm size or land limitations	1	4%

Table 7. Effects of challenges on farm production and income

Effect	Frequency	Percentage
Reduced crop yield	25	100%
Reduced income	24	96%
Increased production costs	6	24%
Difficulty selling or low market price	6	24%
Insufficient production	5	20%
Crop damage or losses	3	12%

All respondents identified financial constraints as a challenge, while 23 respondents or 92% mentioned market access issues or low prices. In addition, all respondents reported reduced yield, and 24 respondents or 96% reported reduced income. These findings show that soil management problems are connected with wider socioeconomic limitations. Improved practices should therefore be practical, affordable, and supported by institutions rather than dependent only on individual farmer spending [13].

Table 8. Farming goals and priority support needs of respondents

Farming goal / support need	Frequency	Percentage
Increase yield	22	88%
Improve soil health	14	56%
Reduce costs	8	32%
Sustainability	3	12%
Financial assistance	22	88%
Farm equipment or machinery	21	84%
Access to government programs	20	80%
Fertilizers and other inputs	20	80%
Quality seeds or planting materials	18	72%
Post-harvest facilities	17	68%
Irrigation or water supply improvement	16	64%
Transportation or logistics support	14	56%
Climate-resilient technologies	13	52%
Better market access or fair pricing	12	48%
Pest and disease management support	11	44%
Technical support or extension services	10	40%
Training or seminars	8	32%

The most common farming goal was to increase yield, reported by 22 respondents or 88%. More than half of the respondents also wanted to improve soil health. The major support needs were financial assistance, farm equipment, access to government programs, fertilizers and inputs, quality seeds, post-harvest facilities, and irrigation improvement. These results suggest that soil improvement programs in Barangay Sugod should be linked with livelihood support, input access, training, and market assistance.

3.4 Soil probe and laboratory results

Table 9. Consolidated soil probe results of selected rice and corn farm sites

1. Farm site	2. Temperature (C)	3. Moisture (%)	4. EC (dS/m)	5. Salinity (mg/L)	6. N (mg/kg)	7. P2O5 (mg/kg)	8. K2O (mg/kg)	9. pH
10. Rice farm site	11. 27.51	12. 47.91	13. 0.13 (Non-saline)	14. 85.13	15. 29.80 (Low)	16. 4.00 (Low)	17. 34.93 (Mostly high)	18. 7.08
19. Corn farm site	20. 29.17	21. 48.03	22. 0.06 (Non-saline)	23. 36.17	24. 16.00 (Medium)	25. 1.67 (Low)	26. 18.17 (Medium)	27. 7.08

The soil probe results showed almost similar average soil moisture in the rice and corn sites. The rice site recorded 47.91% moisture, while the corn site recorded 48.03%. Both sites were interpreted as non-saline based on EC readings. Nutrient readings suggested low phosphorus in both sites. However, field probe readings should be interpreted carefully because soil moisture, calibration, soil contact, and field condition may influence sensor results [7-9].

Table 10. Consolidated soil laboratory results of selected rice and corn farm sites

Farm site	Samples	pH (mean; range)	N	P2O5	K2O	Consolidated interpretation
Rice farm site	5	6.04 (5.8-6.4)	Low	Low	Mostly high	Slightly acidic; low N and P; generally adequate to high K
Corn farm site	3	5.67 (5.4-5.8)	Medium	Low	Medium	Acidic to slightly acidic; medium N and K; low P

The laboratory result for the rice farm site showed a mean pH of 6.04, indicating slightly acidic soil. Nitrogen and phosphorus were low, while potassium was mostly high. The main nutrient concerns in the rice site were therefore nitrogen and phosphorus. For the corn site, the mean pH was 5.67, indicating acidic to slightly acidic soil. Nitrogen and potassium were medium, while phosphorus was low. Thus, phosphorus was the most common nutrient concern in both selected sites.

Low phosphorus is important because phosphorus supports root development, early crop growth, and crop establishment. In rice production, site-specific nutrient management is important for adjusting nutrient supply according to soil properties [10]. In corn production, fertilization practices influence soil nutrients, soil moisture, water-use efficiency, and yield [11]. The low nitrogen result in the rice site also suggests the need for better nitrogen timing and management, particularly because nitrogen efficiency in rice is influenced by water and fertilizer interactions [12].

3.5 Observed physical characteristics of the soil samples

Table 11. Integrated physical characteristics based on field observation and Munsell soil color notation

Farm site	Field observation	Munsell soil color notation	Integrated physical description
Rice farm site	Very moist, sticky, compact, smooth, plastic; formed a cohesive clod with visible root residues.	Mostly 2.5 YR 6/8 and 2.5 YR 6/6 (light red); one sample 2.5 YR 4/4 (reddish brown).	Reddish to reddish-brown, moist, sticky, compact, plastic, and water-retentive.
Corn farm site	Brown to reddish-brown, moderately moist, crumbly, granular, and more friable than the rice soil.	10 YR 4/6, 10 YR 6/8, and 10 YR 6/6 (dark yellowish brown to brownish yellow).	Yellowish-brown to dark yellowish-brown, crumbly, granular, and more friable.

The corn soil appeared crumblier and more friable than the rice soil, suggesting better physical looseness and aeration. The rice soil appeared wetter, more compact, and more plastic, which is consistent with wet rice field conditions where water management affects soil structure, nutrient movement, and soil behavior. These physical observations are useful as descriptive field information, but they do not replace laboratory soil analysis for pH, nitrogen, phosphorus, and potassium interpretation [7,15].

3.6 Relationship between soil characteristics and farmers' management practices

Table 12. Integrated relationship between soil characteristics and farmers' management practices

Soil finding	Related management practice	Interpretation	Practical implication

Low phosphorus in rice and corn sites	Most farmers used fertilizer, but 88% had no soil testing experience.	Fertilizer use may not be fully matched with actual soil nutrient needs.	Promote regular soil testing and site-specific phosphorus management.
Low nitrogen in rice site	Organic material use was very limited; 88% used no organic material.	Rice nitrogen condition may be affected by fertilizer timing, water condition, and limited organic matter return.	Improve split nitrogen application and use safe organic materials when available.
Medium N and K in corn site	Farmers relied mainly on chemical fertilizer or mixed chemical-organic fertilizer.	N and K were not the main limitation in the selected corn site, but imbalance may occur without testing.	Maintain balanced fertilization and avoid unnecessary input use.
Slightly acidic rice soil and acidic to slightly acidic corn soil	Only 12% had soil testing and only 4% had technical assistance.	Farmers may not be fully aware of soil acidity and its effect on nutrient availability.	Encourage routine pH testing and technical guidance before amendments.
Moist, sticky, compact rice soil	Conventional tillage was common, and rice fields are wet environments.	Physical condition may influence drainage, aeration, and fertilizer behavior.	Improve water management, drainage, tillage timing, and organic matter return.
Soil erosion reported by 60%	Only 44% reported any conservation-related practice; 56% reported none.	There is a gap between erosion problems and soil protection practices.	Promote mulching, cover crops, contour farming, grass strips, and reduced tillage where applicable.
Probe pH differed from laboratory pH	Probe readings were collected under field conditions.	The probe should support, not replace, laboratory soil testing.	Use sensors for quick monitoring but confirm major decisions through laboratory analysis.

The evaluated findings show that the most important soil fertility issue in both selected farm sites was low phosphorus. This is important because most farmers reported using fertilizers, yet phosphorus remained low in the laboratory results. This suggests that fertilizer application may not be fully aligned with actual soil nutrient needs. Site-specific nutrient management is therefore necessary because fertilizer application should be based on soil test results, crop requirements, and field conditions [10,11].

The pH results also support the need for regular soil testing. The laboratory result showed slightly acidic soil in the rice site and acidic to slightly acidic soil in the corn site, while the soil probe showed near-neutral pH in both sites. Because of this difference, laboratory pH should be considered the main basis for chemical interpretation. Field sensors are useful for rapid monitoring, but their readings can be affected by calibration, soil moisture, and contact conditions [7-9].

Overall, the relationship between soil physico-chemical characteristics and farmers' management practices suggests that the selected farm sites may benefit from regular soil testing, site-specific fertilizer management, improved phosphorus management, better nitrogen management for rice, increased use of organic materials, and stronger soil conservation. However, because the study was descriptive and site-specific, the findings should be presented as baseline and associative rather than causal.

IV. CONCLUSION AND RECOMMENDATIONS

The study concluded that the farmer-respondents in Barangay Sugod were mainly dependent on crop production; therefore, soil quality is an important factor in their productivity, income, and long-term livelihood. Many respondents perceived their soil as moderately fertile, but soil erosion was commonly reported and previous soil testing was limited. Most respondents practiced monocropping, conventional tillage, chemical fertilizer use, limited organic material application, and limited conservation practices.

The selected rice site was slightly acidic and had low nitrogen and phosphorus but mostly high potassium. The selected corn site was acidic to slightly acidic and had medium nitrogen and potassium but low phosphorus. Thus, phosphorus management should be prioritized in both sites, while nitrogen management should also be improved in the rice site. The soil probe was useful for quick field observation, but its pH readings differed from laboratory values; therefore, laboratory analysis should remain the main basis for chemical interpretation.

The findings also show that soil problems cannot be separated from socioeconomic and institutional constraints. Financial limitations, market issues, labor shortage, limited technical assistance, and low access to organic inputs may prevent farmers from adopting improved soil management practices. Recommendations should therefore be affordable, locally available, group-based, and supported by the barangay, LGU, MAFAR, extension workers, farmer groups, and academic institutions.

Table 13. Priority practical action plan for Barangay Sugod

Priority concern	Practical action	Possible implementer	Why it fits low-income farmers
Low soil testing	Conduct free or subsidized soil testing before planting season.	LGU, MAFAR, barangay, MSU or nearby soil laboratory	Reduces individual testing and transport cost.
Low phosphorus in rice and corn sites	Give soil-test-based phosphorus fertilizer advice and avoid uniform fertilizer use.	MAFAR, city agriculture office, extension workers	Helps farmers buy only nutrients most needed by the crop.
Low nitrogen in rice site	Promote proper timing and split application of nitrogen.	Extension workers and farmer leaders	Improves fertilizer efficiency and reduces waste.
Low organic material use	Use composted crop residues, rice straw, corn stalks, weeds, and safe manure when available.	Farmers, farmer groups, barangay, MAFAR	Uses materials that may already be available locally.
Soil erosion	Use mulching, grass strips, contour planting, drainage cleaning, and cover crops where possible.	Farmers, barangay, LGU, extension workers	Low-cost practices can reduce soil loss without expensive equipment.
Limited technical assistance	Schedule regular farm visits and simple training on soil test interpretation, fertilizer timing, and erosion control.	MAFAR, LGU, MSU agriculture faculty or students	Brings technical advice directly to farmers.
High input cost and poor market access	Organize group buying of inputs and group selling of produce.	Farmer organizations, cooperative, barangay, LGU	Reduces individual cost and strengthens bargaining power.

For farmers, the study recommends requesting soil testing before fertilizer application, prioritizing phosphorus management in both rice and corn areas, improving nitrogen timing in rice, using safe and locally available organic materials, avoiding unnecessary burning of residues, adopting simple erosion control practices, reducing repeated tillage when possible, and keeping simple farm records.

For local institutions, the study recommends free or subsidized soil testing, simple interpretation of soil test results, soil-test-based fertilizer distribution, community composting, demonstration farms, strengthened soil conservation support, regular extension visits, and linking soil management with livelihood support. Future studies should include more farm sites, use composite soil sampling, include additional soil health indicators, compare calibrated sensor readings with laboratory results, and conduct cost-and-yield analysis of recommended practices.

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