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Physico-Chemical Assessment of Rice Soils in Quirino Province, Philippines

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Abstract

Optimum crop production is achievable with scientific soil analyses. Thus, the study was conducted in Quirino province covering rainfed and irrigated rice fields. The purpose of this study is to establish an updated database on the physical and chemical properties of these soils which intends to guide farmers in their rice farming activities, particularly on soil management. Results of the soil physicochemical analysis revealed that irrigated rice soils from Aglipay are Loam to Sandy Loam with a pH of 5.7-6.1 (medium acidic to slightly acidic) while rainfed soils are clayey with a pH of 5.3-7.1 (with strongly acidic to very slightly alkaline found to be generally). Samples collected from irrigated rice areas of Cabarroguis are majority Silty Loam with a pH of 5.8 (medium acidic), and soil samples from rainfed areas are found to be Clay Loam with a pH of 5.7 (medium acidic). On the other hand, samples gathered from irrigated areas of Diffun are dominated by Silt Loam with pH ranges from 5.4-6.3 (medium to slightly acidic); while samples from rainfed areas Clay to Clay Loam and pH of 4-5.5 (strongly acidic). Irrigated soil samples collected from Maddela are Loamy to Sandy Clay Loam with a pH ranging from 5.4-6.3 (medium to slightly acidic); while samples from rainfed were revealed to be silty Loam with a pH of 4.6 (strongly acidic). Irrigated rice soils of Nagtipunan are sandy clay with a pH 0f 6.0 (slightly acidic) while rainfed areas are found to be Clay Loam and Sandy Clay with slightly acidic to very slightly alkaline pH.With this current status of rice soils in the area, it is suitable for rice production. Furthermore, the soils assessed are also suitable for other high-value crops to avoid a monocropping system of farming.

Keywords: crop suitability, irrigated, physico-chemical, rainfed, soil management.

INTRODUCTION

Soil is one of the important and valuable resources of nature. All living things are directly and indirectly dependent on soil for day-to-day needs and all the human food is derived from the earth. Making a plan for having healthy and productive soil is essential to human survival. Soil has a complex function that is beneficial to humans and other living organisms. It acts as a filter, buffer storage, and transformation system and thus, protects the global ecosystem against the adverse effects of environmental pollutants. Environmental neglect by society, since the dawn of the industrial revolution, has resulted in severe contamination of soil and water resources (Ramaswamy et al., 2007). Soil formation is a constructive as well as destructive process (Pujar et al, 2012) the predominant destructive process is the physical and chemical breaking down of materials, plants, and animal structures which results in the partial loss of more soluble

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and volatile products. Soil types are a major factor in determining what types of plants will grow. The nature of soil primarily depends upon its continued change under the effect of physical factors like the parent material, time, the climate, the organic activity in it, etc. (Solanki and Chavda, 2012). Although all physicochemical properties are involved in soil functioning, biochemical properties tend to react most rapidly to get changes in the external environment (Trasar-Cepeda et al, 2008). The soil varies in physical properties and constitution, chemical properties and composition, and biological characteristics. The chemistry of soil covers the chemical reaction process in the soil pertaining to plant and animal growth and human development (Ashraf, 2012).

This research study was conducted to evaluate the fertility status of Quirino rice soils and for the establishment of balanced nutrients that has been supplied in the soil through long-time fertilization. Farmer end-user will be guided for the facilitation of a higher yield and sustain rice production to meet the demand in the country.

MATERIALS AND METHODS

Locale of the Study

The study was conducted in Quirino Province. Quirino lies in the southeastern portion of Cagayan Valley. It is situated within the upper portion of the Cagayan River basin and bounded by Isabela on the north, Aurora on the east and southeast, and Nueva Vizcaya on the west and southwest.

The 10,085 hectares of irrigated and 1,254 hectares from rainfed rice fields in Diffun, Cabarroguis, Saguday, Aglipay, Maddela, and Nagtipunan were the sources of soil samples for the study. In the soil sample areas, the following were considered, the slope, color, drainage, and texture of the soil.

Chemical Analysis of Sample Soil

Soil samples were analyzed using the Flame Photometer and Spectrophotometer. In the soil analysis, the chemical properties such as OM, N, P, K, and soil pH were determined.

Physical Analysis of Sample Soil

To analyze the soil texture, the soil triangle method was used. Part of the mixed soils from the different sub-samples was also used. Glass jars of the same sizes were filled with 25% soil. After putting the soil in the jar, water was added leaving a space at the brim of the jar, then shaking the mixture. Leave the mixture for at least 30

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seconds. The sand is observed to settle at the bottom of the jar. Mark the height of the sand. Leave the glass for 24 hours, and then measure the second layer which comprises the silt and the last layer is the clay. After measuring the height of the soil texture, the total measurement was determined by adding all the heights to come up with the total. Each measurement was divided by the total and then multiplied by 100 to get the percentage. These percentages were graphed in the soil texture triangle. The point at which these three lines intersect defines the soil's texture.

RESULTS AND DISCUSSION

A. Physical Characteristics

There were five soil series identified in the province cultivated for rice (Godillano, 2005). Table 1 shows the physical properties of soils used for rice production.

Table 1. Physical Characterises of soils cultivated for lowland and upland rice in Quirino Province

Municipality	**Barangay**	**Series**	**Texture**	**Drainage**
A. Lowland Rice				
Aglipay	San Francisco	Rugao	Loam	Fair to good
			Sandy Loam	good
Cabarroguis	Zamora	Rugao	Silt loam	Poor
	Gundaway	Rugao	Silt Loam	Poor
Diffun	San Antonio	Rugao	Silt loam	Poor
			Sandy Loam	Good
	Aurora East	Rugao	Silt loam	Good
	Aurora West	Rugao	Silt loam	Good
	Liwayway	Rugao	Clay Loam	Moderate
	Guribang	Annam	Clay	Poor
Maddela	Cabaruan	Luisiana	Sandy clay loam	Good
	Cabaruan	Luisiana	Loam	Fair to good
Saguday	Magsaysay	Alaminos	Clay	Poor
	Magsaysay	Alaminos	Sandy clay loam	Good
	Dibul	Rugao	Loam	Fair to good
	Tres Reyes	Cauayan	Silt Loam	Poor
	Dibul	Rugao	Silt Loam	Poor
B. Upland Rice				
Aglipay	Cabugao	Rugao	Clay	Poor
	Cabugao	Rugao	Clay	Poor
Cabarroguis	Gundaway	Rugao	Clay loam	Poor
Diffun	Diego Silang	Rugao	Clay	Poor
	Ma. Clara	Rugao	Clay Loam	Poor
Maddela	Dipintin	Rugao	Silt Loam	Fair
Nagtipunan	San Dionisio	Rugao	Clay Loam	Fair
	Pongo	Rugao	Sandy clay	Good
Saguday	Gamis	Rugao	Silt Loam	Fair

Alaminos Series. The soil is a member of the fine, isohyperthermic Typic Kanhaplustults (Soil Survey Staffs, 1994). The soils were residuals derived from the weathering of basalts and andesitic rocks. As a ultisol, it has low base saturation and pH, which contribute to the relatively low fertility of the soil. The topography varies from sloping to steep and it is characterized by its brown to reddish brown soil which

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indicates that the internal and external drainage is good. Alaminos clay and Alaminos sandy clay loam both in Magsaysay; Saguday is located on the back slope of a high basaltic hill that is moderately deep to deep.

The surface soil is reddish-brown silt clay. The structures in the topsoil are moderate, medium to coarse sub-angular blocky while consistencies are slightly sticky to sticky, slightly plastic to plastic when wet, and firm when moist. There were few to common partially and highly weathered rock fragments found in the lower horizons.

The inherent soil fertility is low to very low, as indicated by its low organic matter content and pH, base saturation, and cation exchange capacity. Secondary-growth forests and grasses are the vegetation in the hilly and rugged areas while the rolling and level areas are mostly of parang type of vegetation. Some of the level areas, however, are cultivated with rice, corn, and vegetables.

Annam Series. The moderately deep to deep, well-drained soils developed from the weathering basalt and andesite on undulating to steep terraces, and foot slopes of hills and mountains were classified as fine, loamy, isohyperthermic Typic Eustrustox (Badayos, et al, 2007).

The soils are intensely weathered and generally predominated by the oxides of irons and aluminum due to repeated high precipitation and high temperatures. They have low to medium inherent soil fertility because of their low to medium base saturation and the soil reaction is moderately acidic. They are generally dark brown, very dark grayish brown, strong brown, reddish brown to reddish yellow with common to many parts and highly weathered rock fragments.

Annam clay (Guribang, Diffun) is characterized by its fine texture, brown to dark brown surface horizons, and good structure. Structures are moderate fine to medium sub-angular blocky to granular. Consistencies are slightly sticky to sticky and slightly plastic to plastic when wet and firm to friable when moist. The soil is slightly sticky to sticky, slightly plastic to plastic when wet; and firm when moist. There were a few parts and highly weathered rock fragments present in the lower horizons.

Cauayan Series. The soil is a member of very fine kaolinitic isohyperthermic Typic Kanhaplustults, (Barrera et al., 1953; Dayot et al., 1993). Cauayan soils were developed from pre-existing old alluvium mostly originating from sandstone. The presence of rounded gravels in the substratum signifies their mode of formation. The soil in Tres Reyes, Saguday used for lowland rice production shows that the external drainage of these soils is well-drained, medium-textured, and dominantly brown in color. Internally, morphological properties exhibit poor drainage conditions due to semi-permeable layers of iron and manganese in the lower subsoil.

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The thick surface horizon is dark brown with reddish streaks. The structure is moderate to strong sub-angular blocky, slightly sticky, and slightly plastic when wet and firm when moist. The subsoil is gritty, and compact, hard clay with few iron and manganese concretions which merge gradually with the substratum. Large portions of the soil are grassland which somehow reflects the low fertility; some areas with adequate irrigation are used for paddy rice.

Luisiana Series. Soils under this series are classified as fine clayey, acidic, deep, illitic, isohyperthermicOrthoxicPalehumults. These are upland dark red soils developed from hard igneous rocks such as andesite and basalt in roughly rolling to hilly relief. The soil is deep to very deep and well-drained, fairly friable, reddish brown, dark brown, or red. Structures are moderate to strong angular blocky and have sticky and plastic consistency when wet. The relief is usually rolling too steep.

Soils in Cabaruan, Maddela are typical of soil under this series. The surface soil is friable when moist, slightly hard when dry, and slightly sticky and plastic when wet. The clayey surface has strong brown and brown to dark brown, with few manganese and iron concretions. The permeability of the soil is moderate while the external drainage is good. Vegetation is cogon and tree crops.

Rugao Series. The soil is a member of fine isohyperthermic Aquic Haplustalfs (Costelo, 2002; Soil Survey Staff, 1994). These soils are fine textured, fine granular in structure, deep to very deep, moderately well-drained, and with moderate to high fertility. These were developed from shale and sandstone. The color of the different layers is more or less alike and concretions exist from the surface to the substratum. The majority of soils in the province cultivated for lowland and upland rice is under this soil series. The clayey surface soil is brownish black, with medium sub-angular blocky to granular structures, slightly sticky to sticky and slightly plastic-to-plastic when wet and friable to firm when moist has few medium and coarse manganese concretion and partially and highly weathered shale fragments.

The drainage of Rugao clay loam is well-drained and moderately well-drained, respectively. Permeability is slow to moderate. The soil is mainly used for corn production in gently sloping to undulating areas whereas in rolling areas are wide species of shrubs and grasses. Some areas were terraced and used for rainfed paddy rice.

These soils are found in uplands derived through the weathering of the various igneous rocks, shale calcareous sandstone coralline limestone. The relief varies from gently sloping, rolling to hilly mountainous. The topsoil considered as the plow layer of the lowland soils was mostly clay, loam, and clay loam while soils in the upland had five textural classes, namely clay, clay loam, sandy clay loam, and silt loam.

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B. Chemical Properties

Table 2. Chemical characteristics of soils cultivated for lowland and upland rice in Quirino Province

	Barangay	Series	pH	OM (% N)	P ppm	K ppm
		A. Lowland Rice				
Aglipay	San Francisco	Rugao	5.7	0.9	13	25
			6.1	1	12	25
Cabarroguis	Zamora	Rugao	5.8	2.5	20	100
	Gundaway	Rugao	5.8	2.3	18	205
Diffun	San Antonio	Rugao	5.8	2	10	210
	Aurora East	Rugao	5.6	2.3	14	45
	Aurora West	Rugao	6.3	1.8	7	65
	Liwayway	Rugao	5.4	2.2	13	60
	Guribang	Annam	6.1	1.7	84	80
Maddela	Cabaruan	Luisiana	5.4	3.3	96	300
	Cabaruan	Luisiana	6.3	2.7	56	250
Nagtipunan	San Dionisio	Rugao	6.0	2.1	45	105
Saguday	Magsaysay	Alaminos	5.4	1.1	6	600
	Magsaysay	Alaminos	4.7	1.8	12	40
	Dibul	Rugao	4.7	1.9	7	75
	Tres Reyes	Cauayan	4.7	1.8	14	45
	Dibul	Rugao	4.9	1.8	9	60
		B. Upland Rice				
Aglipay	Cabugao	Rugao	7.1	1.5	9	105
	Cabugao	Rugao	5.3	2.8	12	165
Cabarroguis	Gundaway	Rugao	5.7	2.6	17	185
Diffun	Diego Silang	Rugao	5.4	1.9	46	80
	Ma. Clara	Rugao	5.5	4.1	173	85
Maddela	Dipintin	Rugao	4.6	1.5	9	65
Nagtipunan	San Dionisio	Rugao	6.3	1.4	57	205
	Pongo	Rugao	7.3	1.6	119	205
Saguday	Gamis	Rugao	5.1	1	5	95

As shown in Table 2, the pH of sampled soils ranged from 4.7 to 6.3 (lowland rice) and 5.1 to 7.3 (upland rice). In the plow layer of the soils, Soils in Saguday registered a very strongly acidic reaction at pH 4.7 while Buguey registered a mildly alkaline reaction at pH 7.4. A similar trend was observed in upland soils where pH increased with depth except for Sibul where it decreased from 6.8 to 5.8. The soils in the upland exhibited lower pH than the soils in the plain which range from very strongly acidic (pH 4.5) to slightly acidic (pH 6.8).

In the surface horizon, Rugao and Alaminos registered the lowest pH with 4.5 and 4.8, respectively while Bolinao and Sibul with respective pH of 6.7 and 6.8 obtained the highest pH levels. In contrast with pH, the organic matter content of the soils decreased with depth. Moreover, higher levels of organic matter were obtained on the soils in the upland than on the soils located in the plain. In the plow layers, organic matter content among the soils in the upland soils ranged from 1.53 (Sibul) to 6.88 (Bolinao) while the soils in the plain had 0.64 (Buguey) to 4.01 (Bantog).

Furthermore, among the extractable bases of the soil, calcium is the dominant cation followed by magnesium, sodium, and potassium. Sodium and potassium are generally low in all soils. The soils in the valley registered higher values of these bases than the soils in the upland. The cation exchange capacity of the lowland soils was higher than the cation exchange capacity of the upland.

The values increased with depth in the lowland soils while slight changes were observed in the profiles of the upland soils. In terms of base saturation, there was no regular trend in all soils. However, horizons with neutral to mildly alkaline had high extractable calcium compared with those horizons with acidic pH. In general, the phosphorus content of the soils was higher in the plow layers for all the soils. However, there was no observed trend of changes in the lower horizons.

In general, the pH of soils in Quirino are slightly too strongly acidic. Saguday registered the highest acidity in the lowland areas followed by Diffun. On the other hand, Maddela registered the highest acidity in the lowland areas followed by Saguday and Diffun. Based on the foregoing results, it can be said that the pH of soils in the lowland areas is much more acidic than the soils in the upland areas.

On the other hand, it can also be gleaned on the table that there is a very low amount of nitrogen in the soil sample across the municipalities of Quirino, soil texture, and acidity. However, the phosphorus and potassium content of the soils are higher but of no considerable trend or pattern. Owing to the foregoing results, farmers and agricultural technicians would employ qualitative analysis for better crops based on the physical and chemical characteristics of the soil in the area.

CONCLUSIONS AND FUTURE WORKS

Based on the study, the following were the conclusions:

1.Quirino rice soils have a pH range of 4.6-7.3 with a general soil type of clay to sandy clay loam. These indicate the suitability for rice production; provided that other factors and requirements are included for optimum production.

2.There are other high-value crops that are highly suitable and moderately suitable for production in the Quirino rice soils; provided proper cultural management and other factors are appropriately considered;

3.Limiting nutrients can be applied following the computed fertilizer recommendation rate.

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