The Cation Exchange Capacity, pH of Soil in Mwogo Marshland, and the Rice Plantation in Huye District -Rwanda

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Abstract— *Agriculture is a major component of Rwanda's national economy. In 2017, agriculture contributed 33% to the country's GDP. About 66.46 % of population, of which 50.9 % are women, depends either directly or indirectly on agriculture for living. The average arable surface area available is about 0.60 ha per household use. This causes overexploitation of available land which is often accompanied by agricultural malpractices with disastrous consequences on land resources and on environment in general. Given the limited availability of arable land for agriculture and the constantly growing food requirements of the population, ensuring food security poses a major challenge. This present study aimed at investigating the cation exchange capacity and pH of soil of Mwogo Marshaland in order to resolving the problem of soil fertility of Mwogo marshland by looking the method for increasing its fertility and then the problem of low rice production. By using soil Auger, samples were taken randomly in the field where each sample of soil was used in laboratory to determine both pH and Cation Exchange Capacity, in each blocks namely Block du Nord and Block du Sud. During this study the laboratory results and laboratory analysis has shown that marshland soil is very acidity with pHkcl is 4.37, Ph water with a weak cation exchange capacity. These findings support the previous studies showing that the soils with those properties need particular management; like liming, addition of organic matter, and so on, in order to adjust its chemical properties.*

Keywords— Soil, chemical properties, rice production.

I. INTRODUCTION

Soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants (Hazleton and Murphy 2007). The Cation Exchange capacity of soils varies according the type of soil, soil pH and amount of organic matter, for example the pure sand soil is contains low cation exchange capacity, less than 2 meq/100 g. The research of Mckinze stated that soils with large quantities of negative charge are more fertile because they retain more cations (McKenzie *et al.* 2004) however; productive crops and pastures can be grown on low cation exchange capacity soils. The main ions associated with cation exchange capacity in soils are the exchangeable cations calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}) (Rayment and Higginson 1992). However, as soils become more acidic these cations are replaced by H^{+}, Al^{3+} and Mn^{2+}, which affect soil fertility and some plants do not able to grow in that situation (McKenzie *et al.* 2004). As a consequence, Brady (2012) argued that acidic soils, range of hydrologic and climatic condition are affecting growth and production of rice (Brady, 2012).

In small and very densely populated country Rwanda, the average arable surface area available is about 0.60 ha per household lead people to overexploit land activities, convert pastures and woodlots into cropland and cultivate in malpractice which fragmented, fragile, steep-sloping of areas and cause also soil infertility (Imerzoukene and Van Ranst, 2001). Other characteristics of the subsistence agriculture in Rwanda are the lack of individual and regional specialization, a weak integration between agriculture and the economic markets, and an important dependence on the climatic conditions which resulting a serious decrease of the physical and chemical soil fertility and affect crop yields (Imerzoukene and Van Ranst, 2001).

Rice plantation has been adapted as major crop need empowerment in Rwanda in order to cop that challenge of food insecurity. In the past 10 years, the total rice production has increased by 6-fold from 11,949 tons in 2000 to 72,000 tons in 2009. Rwanda annually imports Tanzanian, Indian and Pakistan long grain rice: 57,229 MT (2012) while Rwanda produced only short grain rice (Kigori): 81,908 MT (2012) which is very low compare to the needs of population and lead the rice consumption be outstripped to the local production.

In the same case, the rice productivity of Mwogo marshland is critical due to the soil nutrient depletion which is directly linked to food insecurity of country and local community. Many factors are associated such as nitrogen, phosphorus, Insufficient mechanization of farming operations, therefore this study was focused on effect analysis of cation exchange capacity and soil ph on soil fertility of Mwogo marshland thereby the soil fertility continues to decline and this declining is showed by low production of rice. This study aims to end up by resolving the problem of soil fertility of Mwogo marshland by looking the method for increasing its fertility. The specific objectives of this study are to: Assess soil PH and cation exchange capacity of mwogo marshland, determine the effect of CEC and soil Ph of Mwogo marshland, to determine strategic way of increasing rice productivity in Mwogo marshland to measure the rate of cations exchange capacity in Mwogo marshland.

II. METHODOLOGY

The marshland of Mwogo is located in southern province, Huye district, on an altitude comprise between 1572 and1715 m above the sea level. The latitude on which mwogo marshland is located on is at $2^0$36' south of the equator; 29^0 49'51'' and29^0 44' East of the Greenwich merdian. Mwogo marshland is about 500ha and is located in Huye district and passes through Rwaniro, Kigoma and Simbi sectors all around the river called Mwogo. It is located in south-east shelf of the tropical agro-climate zone. Soil of Mwogo marshland derives from schisto-quartzites mica material formed at the basin side; the soils are generally clayed, deep, and red with an advanced alteration (Mbonigaba, 2002) .

A simple random sampling was used to select two blocs, where one bloc were taken in northern part of mwogo and another bloc in southern part, three different rice paddy fields(plots) were taken at each bloc and one sample were taken in each plots of the bloc at depth of 20-50 cm below surface with an auger. The collected soil samples were dried for 7days at the normal laboratory temperature and sieved at 2mm for testing soil PH by using deionised water (distilled water) and Kcl. The 25ml of the soil solution was added 10ml of NaOH and put into the distillatory for heating and evaporation. Then after the cooled solution felt down in the beaker containing 5ml of Boric acid and wait 450seconds. The process coloration was changed from reddish to the blue color for titration.

CEC was determined by Metson method which consists of extraction with ammonium acetate 1N at pH 7, followed with distillation and titration by hydrochloric acid 0.1N. In fact, by taking 25ml of the soil solution; and add 10ml of NaOH then put them in the upper part of the distillatory, Below there was a tube containing water. The water was heated until to evaporate. The water vapor heated the mixed solution of the soil sample and NaOH until to evaporate in return. The vapor from the solution was cooled down by the water from the tap circulating in the distillator and removed to fall in lavabo. The cooled solution felt down in the beaker containing 5ml of Boric acid. We stopped the process after 450seconds and then during the process the reddish color changed to become blue.

Thereafter, the solution settled down in three beakers was titled by HCl 0.1N where the following volume of HCL 0.1N were used to titrate solutions in beakers:

Blank : 0.25ml of HCL 0.1N

Soil sample from BlockI : 10.7ml of HCL 0.1N

Soil sample from Block II: 2.6ml of HCL 0.1N

2.1 Titration

- ✓ Titrate solutions in beakers by HCL 0.1N
- ✓ Wait so that the solution color changes to red.
- ✓ Note the volume of HCL 0.1N used.

2.2 Calculations

Correction factor =4

CEC (meq/100g of soil) = titrated volume of sample -- titrated volume of temoin) *4

III. RESULTS

The cation exchange capacity was different from different location of marshland, in northern part of Mwogo, the cation exchange capacity falls in the range of 9.6 and 10.42 within the soil depth of 20-50 cm. as it is shown in table 1 which means that northern part of Mwogo is highly sand soil, Nitrogen and potassium leaching more likely, less lime required to correct a given PH, physical ramifications of a soil with a high sand content, and finally low water holding capacity. In the southern part the cation exchange capacity falls in the range of 7.03-9.34 within the soil profile of 20-50 cm as it is indicated in table 2 which means that the soil of southern part of mwogo is moderated clay.

TABLE 1
CATION EXCHANGE CAPACITY OF NORTHERN MWOGO MARSHLAND

SITE	Plots number	Soil depth (cm)	CEC(cmol/kg of the soil)
NM	Plot no 1	20-50	9.6
	Plot no 2	20-50	9.99
	Plot no 3	20-50	10.42

Legends: NM: Northern Mwogo

TABLE 2
CATION EXCHANGE CAPACITY OF SOUTHERN MWOGO MARSHLAND.

SITE	Plots number	Soil depth (cm)	Cec cmol/kg of the soil
SM	Plot no 1	20-50	9.34
	Plot no 2	20-50	9.20
	Plot no 3	20-50	7.03

The table 3 results showed that CEC of Mwogo marshland has 9.198 which is weak.

This is due to high sand and low clay content, low organic matter due to washing away of the organic matter by a flow of water, low organic matter content, low water-holding capacity which makes bases to leach into the soil, low soil pH and enable to resist on changes in pH or other chemical changes due to high potential of leaching of base cations in the deeper layers of the soil. This weak cation exchange capacity affect the soil properties and the rice crop in faster decrease of soil pH, need to be limed more often, low nutrients available for plant, high amount of essential elements leached into the soil.

TABLE 3
AVERAGE CATIONS EXCHANGE CAPACITY OF MWOGO MARSHLAND

Blocks	Plots	CEC NM	CEC SM	Aver. CEC
B1	plot1	9.6	9.34	9.47
B1	plot2	9.99	9.2	9.595
B1	plot3	10.42	7.03	8.725
B2	plot1	9.7	9.09	9.395
B2	plot2	10	8.91	9.455
B2	plot3	10.1	7	8.55
AVERAGE		9.96833333	8.42833333	9.198

In the part of northern part of mwogo marshland, the soil profile was measured with two methods; pH water and pHkcl and the results are the following: pHkcl falls in the range of 4.30-4.61 which means that the pH of this soil is very acid and pH water falls in the range of 5.30-5.62 which means this soil is fairly acid as it shown in table 4.

TABLE 4
RESULTS OF PH OF NORTHERN MWOGO MARSHLAND SOILS

Sites	Plots number	Soil depth (cm)	pHkcl	pHwater	$\triangle$ pH
NM	Plot no 1	20-50	4.30	5.30	-1.00
	Plot no 2	20-50	4.42	5.55	-1.13
	Plot no 3	20-50	4.61	5.62	-1.01

Legends; NM: Northern mwogo.

In the part of southern part of Mwogo marshland, the soil pH water and pHkcl and the results are in the range of 4.06-4.13 which means that the pH of this soil is very acid and pH water falls in the range of 5.00-5.60 which means this soil is fairly acid as it is indicated in bellow table five.

TABLE 5
RESULTS OF PH OF SOUTHERN MWOGO MARSHLAND SOILS

Sites	Plots number	Soil depth (cm)	pHkcl	pHwater	△ pH
SM	Plot no 1	20-50	4.13	5.04	-0.91
	Plot no 2	20-50	4.18	5.60	-1.42
	Plot no 3	20-50	4.06	5.00	-0.94

Legends: SM: southern mwogo,

The bellow bar chart (figure 2) shows that in Mwogo marshland the cations exchange capacity of the soil increases with the increase of soil Ph as it is indicated by figure 1.

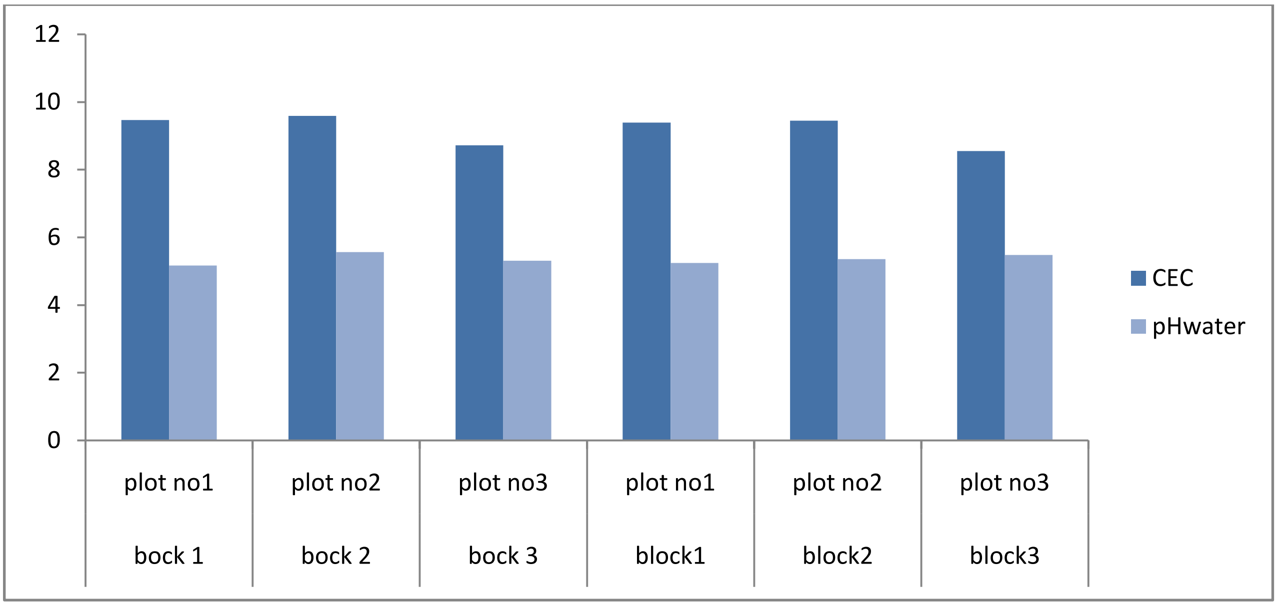

FIGURE 1: Relationship between CEC pH of the soil.

IV. DISCUSSION

In northern part of mwogo, the cation exchange capacity falls in the range of 9.6 and 10.42 within the soil depth of 20-50 cm. this means that northern part of mwogo is characterized by:

High sand content, Nitrogen and potassium leaching more likely, less lime required to correct a given PH, physical ramifications of a soil with a high sand content, and finally low water holding capacity. In the southern part of mwogo marshland, the cation exchange capacity falls in the range of 7.03-9.34 within the soil profile of 20-50 cm.

Average cation exchange capacity of mwogo marshland is 9.19 which means that the soil have weak cation exchange capacity. This is due to high sand and low clay content, low organic matter due to washing away of the organic matter by a flow of water, low organic matter content, low water-holding capacity which makes bases to leach into the soil, low soil pH and enable to resist on changes in pH or other chemical changes due to high potential of leaching of base cations in the deeper layers of the soil.

This weak cation exchange capacity affects the soil properties and the rice crop production decrease of soil pH, need to be limed more often, low nutrients available for plant, high amount of essential elements leached into the soil. The pHwater of the soil of mwogo marshland decreases from the northern mwogo in plot n^{o}3(5.62) to southern mwogo in plot number n^{o}

3(5.00), these are more or less drained profile, they are located not far away from the hillsides, and contain more acidifying cations. But the cations exchange capacity is affected positively; it increases from 7.03 Cmol (+)/kg of the soil in southern mwogo plot number 3 to10.42Cmol (+)/kg of the soil in northern mwogo plot number 3.

This is explained by the fact that there was more organic input from old plants decomposing under the upper layer of the soil, at organic horizon level. The organic matter has capacity to hold the base cations. As it is visible, cations exchange capacity increases and decreases with the Ph. PhKcl decreases from4.61 to 4.06. The average pHwater of mwogo marshland is 5.35 and the average pHkcl of this marshland is 4.3. This affects negatively the exchangeable bases decreasing from 10.42 to 7.03. The phenomenon is explained by the fact that there is a transport of colluviums and alluviums from the hillsides to the valley by the erosion. Recall that this region is one of regions of southern province which register more rainfall.

The PH of mwogo marshland is moderately acidic, the difference between pHkcl and pHwater, shows that these soils are capable to fixe some more cations because they have some negative charges from small amount of organic matter from dead plant and animals. The average soil pHkcl of mwogo marshland falls on 4.37 and the average pHwater of this marshland is 5.35. This means that mwogo marshland is fairly acidic according to Mutwewingabo and Rutunga, 1987, where my research findings coincide with findings of other researchers like Rayment and Higginson 1992, Mutwewingabo and Rutunga, 1987 and McKenzie *et al.* 2004.

The factors of this acidification are the following: accumulation of organic matter which are from hills side due to erosion and high rain fall registered with this region, breakdown of primary minerals (high weathering) and leaching of soluble constituents due to low holding capacity as shown by its soil cation exchange capacity.

Acidity of this marshland affect rice crop through low nutrients absorption, low availability of nutrients, salt effect.

V. CONCLUSION AND RECOMMENDATION

The study showed that soil of Mwogo marshland is acidic soil and its CEC is weak means that mwogo marshland require particular measures for increasing its productivity. Acidic conditions and its cation exchange capacity need to be ameliorated because it is not suitable for better growth of rice. Therefore, we recommend reducing soil acidity, efficient use fertilizer, improving decomposition of crop residues for Ph case while for Cation exchange capacity improvement of CEC in weathered soils by adding lime and raising the Ph is needed. The use organic matter is the most effective way of improving the CEC in this marshland.

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