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Wet and Dry Season Effects on Select Soil Nutrient Contents of Upland Farms in North Bank Region of the Gambia

Ebrima Sonko[1*], Daniel N. Tsado[2], Sidat Yaffa[3], Appollonia A. Okhimamhe[1], Julia Eichie[1]

[1]WASCAL Coordinating Secretariat, Federal University of Technology, Bosso Campus, Minna, Nigeria
[2]School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria
[3]School of Agriculture and Environmental Sciences, University of the Gambia, Brikama Campus, Brikama, The Gambia
Email: *sonkojeleng78@gmail.com

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Abstract

The study was conducted in three villages of North Bank Region of the Gambia in 2013 and 2014. We examined wet and dry season effects on select soil nutrient contents of upland farms in North Bank Region of the Gambia. The objective was to evaluate changes in soil nutrient contents in both wet and dry seasons. Soil samples were collected from three RCBD upland fields with three replications at a depth of 0 - 15 cm and analyzed for pH, Soil Organic Carbon (SOC), and soil moisture content. The gravimetric method of moisture estimation was used. The results showed that soil moisture content, soil TN, and soil pH are significantly different ($P < 0.05$) during the two seasons. There was no significant difference in SOC between the two seasons in the study area. The study concluded that soil nutrients were more readily available during the wet season than during the dry season probably because there is more soil moisture available in the wet season that facilitates soil nutrient release. The study concludes that soil moisture has to be available in order for some select soil nutrients to be released for plant uptake.

Keywords

Soil Nutrients, Wet Season, Dry Season, pH

1. Introduction

Agricultural production systems in The Gambia in general and in the North Bank Region of The Gambia in par-

*Corresponding author.

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ticular are mainly rainfall-dependent. Most farmers in North Bank Region of The Gambia depend on rainfall for agriculture production. Therefore, when there is drought, North Bank Region becomes highly susceptible to crop failure and other livelihood activities that have a direct bearing on agriculture production. Soils in the study area are generally low in soil moisture as a result of erratic rainfall and also low in fertility due to continuous cropping, without much replenishment of soil nutrients by the farmers. Annual depletion rate of primary nutrients from the soils were estimated at as high as 22 kg of nitrogen (N), 2.5 kg of phosphorus (P) and 15 kg of potassium (K) per hectare over the previous three decades of productive uplands in 37 African nations which include The Gambia (Sanchez *et al*. 1997) [1]. North Bank Region of The Gambia is the most prone region of the country to drought because of its low vegetative cover. Although there was research conducted in North Bank Region on the impact of drought on crop production that research did not specifically look at the effect of drought on the content of soil nutrients for plant uptake. That research gap is the need for this study to address so that recommendations could be made on adaptation strategies that could be implemented in order to increase crop production. Because of drought challenges in North Bank Region, Yaffa (2013) [2] suggested that more strategies on soil fertility and water conservation methods should be adopted, horticulture in small irrigated gardens be improved, and drought-tolerant rice cultivars be planted as adaptation activities during drought periods.

Soil moisture deficiency has some implications for sustainable agricultural development. Downing and Bakker (2000) [3] confirmed that adverse weather differs from real weather by its (adverse weather) potential to minimize soil moisture availability for plant uptake for growth and development. Keenan and Krannich (1997) [4] reported that drought impact is felt more on societies with erratic rains than other climatic events that may cause soil nutrient deficiency.

Nitrogen, as a major plant nutrient, for example, is an essential component of proteins, coenzymes, and many other metabolic products and is estimated to represent 2% of total plant dry mass (Miller and Cramer, 2004) [5]. Nitrate and ammonium are the primary sources of inorganic N taken up by plant roots but nitrate is often more available to plants for uptake (Hopkins, 1995) [6]. Hopkins (1995) [6] further reported that nitrogen is often delivered to plant roots by mass flow and diffusion, and thus its availability to plants is highly dependent on soil moisture content. Indeed, drought is often associated with nitrogen limitation (Wang *et al*. 1998) [7], while excessive water flux can result in nitrogen leaching (Parnes, 1990) [8].

The availability of nutrients in the soil interface is dependent on the management strategies applied at the field level over decades. On agriculture soils, nutrient depletion is sparse within the land surface because of intensive utilization of fertilizers for export crops. Nutrient-depleted farms in The Gambia as a result of monocropping are still more common than those without nutrient-depleted soils. Nutrient deficiency rates show large differences with soil properties. For example, Pieri (1989) [9], and Swift *et al*. (1994) [10] reported that a high rate of leaching occurs in sandy soils than in clay soils because of large pore spaces within soil aggregates in sandy soils.

2. Objectives

1) To evaluate changes in soil nutrient contents in both wet and dry seasons.
2) Make recommendations on ways to enhance soil moisture availability to release soil nutrients for plant uptake.

3. Materials and Methods

3.1. Study Area

The research was conducted in North Bank Region of The Gambia which has a population of about 172,835 people (GBOS, 2003) [11]. It lies between Latitude 13˚29'10"N and Longitude 15˚5'48"W. The field work took place in only three districts (Central Baddibou District, Jokadu District, and Upper Niumi District). The Region is characterized by erratic rainfall, poor soil structure, and low soil fertility. The climate is of two different seasons: a wet season (that starts in June and ends in October) and a long dry season (that starts in November and ends in May). The average daily temperature is 30˚C in the dry season and 27˚C in the wet season. Rainfall trends are unpredictable and the annual total is usually less than 800 mm (FAO 2002) [12]. The natural vegetation is mainly savannah woodland and some mangrove trees lining along the banks of River Gambia dissected by an intricate system of water channels. Other areas within the landscape are flood plains and woodlands that are located behind the mangroves.

3.2. Soil Sampling

The locations used for data collection were upland fields in the three Districts. The plots on the fields were used in the study by using a Randomized Complete Block Design (RCBD) with three replications. Soil samples were collected from the replicated plots using a soil probe and screw-type auger. Sukristiyonubowo (2007) [13] method of soil sampling was used to collect soil samples at a depth of 0 - 15 cm and the samples were analysed for pH, Soil Organic Carbon (SOC), Soil Total Nitrogen (TN) and soil moisture content. Soil sampling was done on the 10th and 12th October, 2013 in the wet season and 25th, 26th and 27th January, 2014 in the dry season.

3.3. Soil Analyses

Soil total nitrogen was determined using the micro kjeldahl distillation and titration method described by Bremner, J. M., and C. S. Mulvaney, (1982) [14]. Soil organic carbon (SOC) was determined by a modified Walkley-Black procedure as described by Nelson and Sommers (1982) [15]. The gravimetric method of moisture estimation was used where the soil sample was placed in an oven at 105˚C and dried to a constant weight; this took 24-36 hours. Soil pH was determined using the glass electrode method with a soil-to-water ratio of 1:2

3.4. Data Analyses

SPSS software was used in the data analyses. Significant differences between the select soil contents in the two seasons were determined. The significance level was held at $P < 0.05$

4. Results and Discussion

4.1. Soil Moisture

During the wet season, soil moisture content within the treatment plots fluctuated, which could be attributed to the amount of rainfall and probably the amount of crop biomass at each selected location to conserve moisture in the soil (**Figure 1**). During the wet season, there was no significant difference ($P < 0.05$) in soil moisture content between the three locations (*i.e.* 43% at Njaba Kunda, 41% at Jokadu, and 38% at Niumi Lamin, respectively). In the dry season, on the other hand, although soil moisture content was lower than in the wet season in all three locations (**Figure 1**), still there was no significant difference in between the soil moisture contents. The decrease in soil moisture content could probably be due to high soil moisture evaporation which generally occurs during a drought period. Under an evapo-transpiration rate, utilization of water by crops declines when 50% of the required soil moisture is lost. For example, the water requirement for groundnut production ranges from 500 mm to 700 mm for the production cycle (FAO, 2013) [16]. This shows that the cropping cycle in the North Bank Region could be highly vulnerable to soil moisture loss as a result of drought, which consequently impacts on

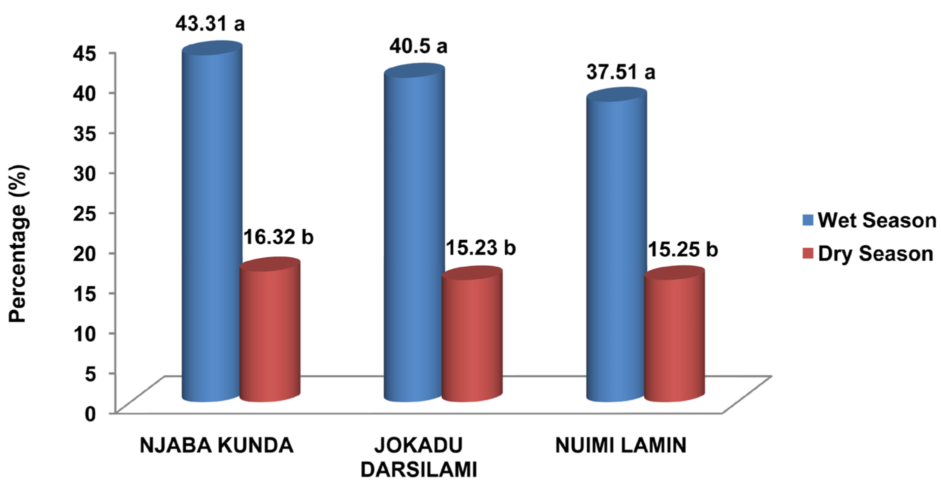

Figure 1. Soil moisture content during wet and dry seasons in three locations in North Bank Region of The Gambia.

crop production and productivity. Water is the primary factor determining soil nutrient mineralization and uptake by crops. Penning de Vries and Djiteye, (1982) [17] reported that Sahel region of Africa highlighted this deficiency in the soil during production seasons. Therefore, crops grown in the North Bank Region could be vulnerable to about 50% water deficiency in the dry season if crop cultivation is also carried out during the dry season.

4.2. Soil pH

The study found no significant difference in soil pH, irrespective of the cropping season, between the three study locations (**Figure 2**). This is an indication that all the three study locations could probably be of the same soil types that are characterized by low pH. Soil pH has a considerable influence on the availability of nutrients to crops. Low soil pH (*i.e*. pH between 1 and 4) which is a highly acidic condition tightly holds soil nutrients which are unavailable for plant uptake. Ronen, (2007) [18] reported that most soil nutrients are available for plant uptake in the pH range of 5.5 - 6.5. These low pH values could be the reason for low availability of nutrients for plant uptake.

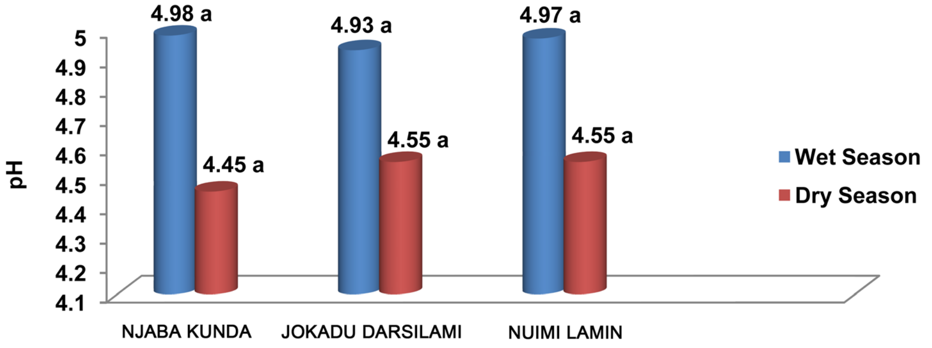

Figure 2. Soil pH content during wet and dry seasons in three locations in North Bank Region of The Gambia.

4.3. Soil Total Nitrogen

Soil total nitrogen recorded for Njaba Kunda, Jokadu, and Niumi Lamin for both wet and dry seasons are shown in **Figure 3**. In either of the growing seasons, soil total nitrogen was less than 1%. This may be attributed to the low crop residue amount that is left on the farms after crop harvest and or low soil moisture which influences nitrogen mineralization for crop uptake as also reported by Wang *et al.* (1998) [7].

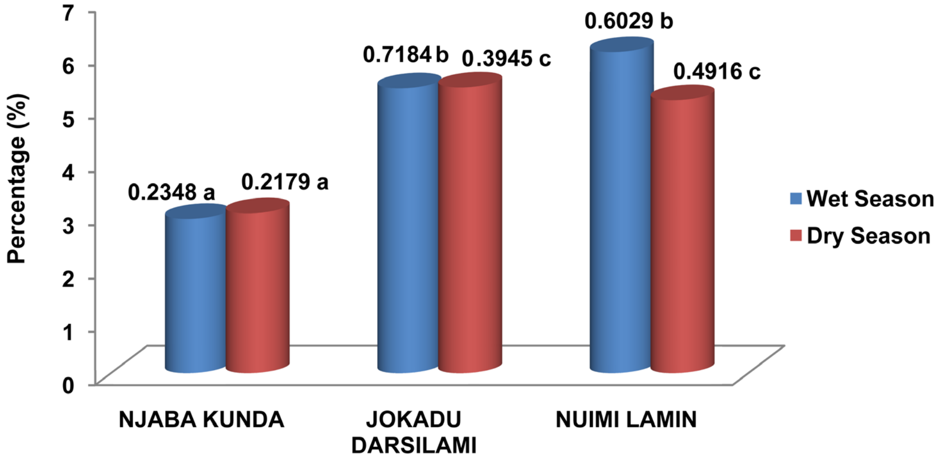

Figure 3. Soil total nitrogen content during wet and dry seasons in three locations in North Bank Region of The Gambia.

Although the soil total nitrogen in either cropping season at either of the three study locations was less than 1%, we found a significant difference in total soil nitrogen between Njaba Kunda and Jokadu Darsilami and Njaba Kunda and Niumi Lamin in either of the seasons (**Figure 3**). This could be probably due to having more crop residues in Jokadu Darsilami and Niumi Lamin, respectively, than in Njaba Kunda that mineralized and released more soil total nitrogen. In Njaba Kunda, the study found no significant difference in soil total nitrogen between the two seasons (**Figure 3**). It was difficult to explain this phenomenon because the study was expected to have more soil total nitrogen in the wet season than in the dry season because of more mineralization as a result of more soil moisture availability. In Jokadu Darsilami, the study found a significant difference in soil total nitrogen between the wet and dry seasons. There was about twice more soil total nitrogen in the wet season than in the dry season at Jokadu Darsilami. This was probably that in the wet season, there was more mineralization of nitrogen than in the dry season. In Niumi Lamin, there was about one and a half times more soil total nitrogen found in the wet season than in the dry season (**Figure 3**). Again, just like in Jokadu Darsilami, probably there was more nitrogen mineralization during the wet season than in the dry season in Niumi Lamin (**Figure 3**). There was no significant difference in soil total nitrogen, irrespective of the season, between Jokadu Darsilami and Niumi Lamin (**Figure 3**). This could be that in both Jokadu Darsilami and Niumi Lamin there could have been similar amounts of nitrogen mineralization.

4.4. Soil Organic Carbon

Soil organic carbon content among the three study locations is shown in **Figure 4**. Irrespective of the study location, there was no significant difference between the two seasons in terms of soil organic carbon content (**Figure 4**). However, there was a significant difference in soil organic carbon content between Njaba Kunda and Jokadu Darsilami and Najaba Kunda and Niumi Lamin (**Figure 4**), respectively. This could be probably due to more crop residue found in both Jokadu Darsilami and Niumi Lamin than in Njaba Kunda. Irrespective of the season, there was no significant difference in soil organic carbon content between Jokadu Darsilami and Niumi Lamin (**Figure 4**). Low soil organic carbon content in the three study locations is supported by findings byWilliams and Balling (1994) [19] which states that African soils, and mostly those of West Africa, have low inherent fertility as a result of low crop residue cover of the soils. The same authors went on further to state that soil fertility depletion (mainly N, P, and C) is the primary factor hindering food security in West Africa.

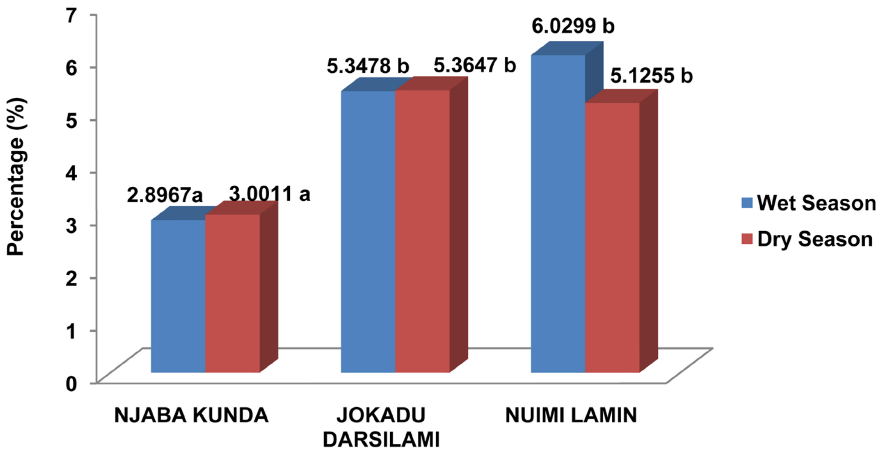

Figure 4. Soil organic carbon content during wet and dry seasons in three locations of North Bank Region of The Gambia.

5. Conclusion

Soil moisture content, which ranges between 37.51% and 43.31%, is below optimum soil moisture requirements of 50% for good crop growth and development. The study concludes that the soil pH of both wet and dry seasons are acidic and below the required pH range for crop productivity *i.e.* 5.5 to 6.5. Meanwhile, soil total nitrogen in the study area was less than 1% in either of the seasons whereas soil organic carbon content ranged between 2.8967% and 6.0299% in both seasons. These were still found to be less than 7% which is ideal for optimum crop production. Therefore, seasonal variation on soil nutrient level has called for sustainable soil fertility management practices that would enhance food security in the North Bank Region of The Gambia, in particular and in The Gambia as a country.

6. Recommendations

1) Do not remove much of the crop residue from the soil surface after crop harvest so that more soil moisture can be retained for plant uptake and nutrient mineralization.
2) Incorporation of crop residues in the soil should be encouraged so that soil carbon and soil nitrogen could be increased.
3) Supplemental crop irrigation should be encouraged in order to avert drought impacts on crop production in the Region.

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