

Investigation of Physico-Chemical Properties of Soils from Cassava Fields Infested with Root Rot Disease in the Selected Districts, Brong Ahafo, Ghana

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Abstract:

Cassava root rot is a serious threat to cassava production worldwide. It reduces yields and adversely affects the growth of the crop. Depending on the causal agent, host susceptibility, and the environmental conditions, entire fields can be lost to this disease. A research was carried out in the Nkoranza South, Sunyani West and Dormaa East districts of the Brong Ahafo Region of Ghana to assess the physico-chemical properties of soils from fields infested with cassava root rot disease. Composite soil samples were taken from infested and non-infested cassava fields at two different depths (0 – 20 cm and 20 – 40 cm). Samples from the non-infested fields served as control. The samples were transported to the laboratory for analysis of pH, organic matter, nitrogen, phosphorus, potassium, calcium and effective cation exchange capacity. Generally, the results showed low to moderate levels of plant nutrients in the soil samples from both the infested and non-infested cassava fields in the three districts of Brong Ahafo Region. Plant nutrients may be said to have been depleted and to increase cassava yields the major plant nutrients i.e. nitrogen, phosphorus and potassium should be increased by applying chemical fertilizers.

Keywords:

Cassava, Root Rot, Disease, Districts, Fertilizers, Plant Nutrients

1. Introduction

Cassava (*Manihot esculenta* Crantz) is considered to be one of the important crops in tropical and subtropical areas due to its importance in the composition of animal and human food. In the industrial sector cassava is also important because it is among the five commodities (maize, sugar cane, soy, cassava and oil palm) in bioethanol production and used in the production of biodiesel and biogas (Naylor et al., 2007). Unfortunately, most of the cassava production is from lands of the smallholder

farmers, who pay little or no attention to the physiological and sanitary quality of the cuttings used. Cassava production is affected by diseases such as mosaic disease, brown leaf spot (*Cercosporidium henningsii* Allesch), white leaf spot (*Phaeoramularia manihotis*), and anthracnose (*Colletotrichum gloeosporioides* (Penz.) F. sp. *manihotis*) (Morais et al., 2014) and root rot caused by fungi such as *Phytophthora* spp., *Fusarium solani* (Mart.) Sacco and *Scytalidium lignicola* Pesante and *Lasiodiplodia theobromae* (Notaro et al., 2013; Akrofi et al., 2016). Most studies in Ghana focus on the existing cassava root rot caused by *Polyporus sulphureus* (Opoku-Asiamah et al., 1998; Moses et al., 2007; Awaga, 2004).

Cassava root rot disease, which is caused by soil borne fungi such as *F. solani*, can survive in plant debris or in the soil through resistance structures as chlamydospores for a long time (Awaga, 2004), also in the form of spores or mycelium diseased or dead tissue. Control of cassava root rot disease is very difficult and handling with chemicals is expensive and almost inefficient, besides causing serious pollution to the environment with pesticides, the use of resistant varieties and cultural practices are important strategies in management of this disease. Several research have demonstrated how the power of soils suppresses diseases caused by soil borne fungi such as *Fusarium oxysporum*, *Pythium* sp., *Rhizoctonia solani*, *Streptomyces saran* and *Scytalidium lignicola* (Mazzola and Gu, 2002; Silva et al., 2013).



Figure 1. Samples of cassava tubers with symptoms of root rot.

Mostly, plants suffering nutrient stress will be less vigorous and more susceptible to a variety of diseases. In this respect, almost all nutrients affect plant diseases. The disease is considered to be browning and wilting of leaves, defoliation of the stem, shoot dieback, breakage of stem at the base, lodging and wilting of the whole plants together with rotting of the tuberous root (Bua and Okello, 2011).

Awaga 2004, studied the extent of spread of *Polyporus sulphureus* and identify the cassava varieties resistant to the disease and evaluate control measures adopted by farmers in the central region. The results showed that the *Polyporus sulphureus* was prevalent in 3 out of 15 towns covered in the field survey. The fungus was present in all the types of soils considered throughout the year and infected cassava plants were between the ages of two and twelve months. Moses et al., 2007 quantified the incidence and severity of *Polyporus sulphureus*, evaluate its host range, identified the cultural practices that stimulate the spread and persistence of the disease and screened cassava varieties for resistance to the disease in Southern Ghana. Results also revealed that *Polyporus sulphureus* is present Volta, Ashanti and Central Region of Ghana.

Recent reports indicated that root rot disease common in fields with matured cassava plants in Brong Ahafo Region of Ghana. It was within this domain that a research was conducted in the Brong Ahafo Region to assess the physico-chemical properties of soils in cassava root rot disease infested and non-infested fields. This research was supported by West Africa Agricultural Productivity Program (WAAPP).

2. Materials and Methods

2.1. Description of the Study Area

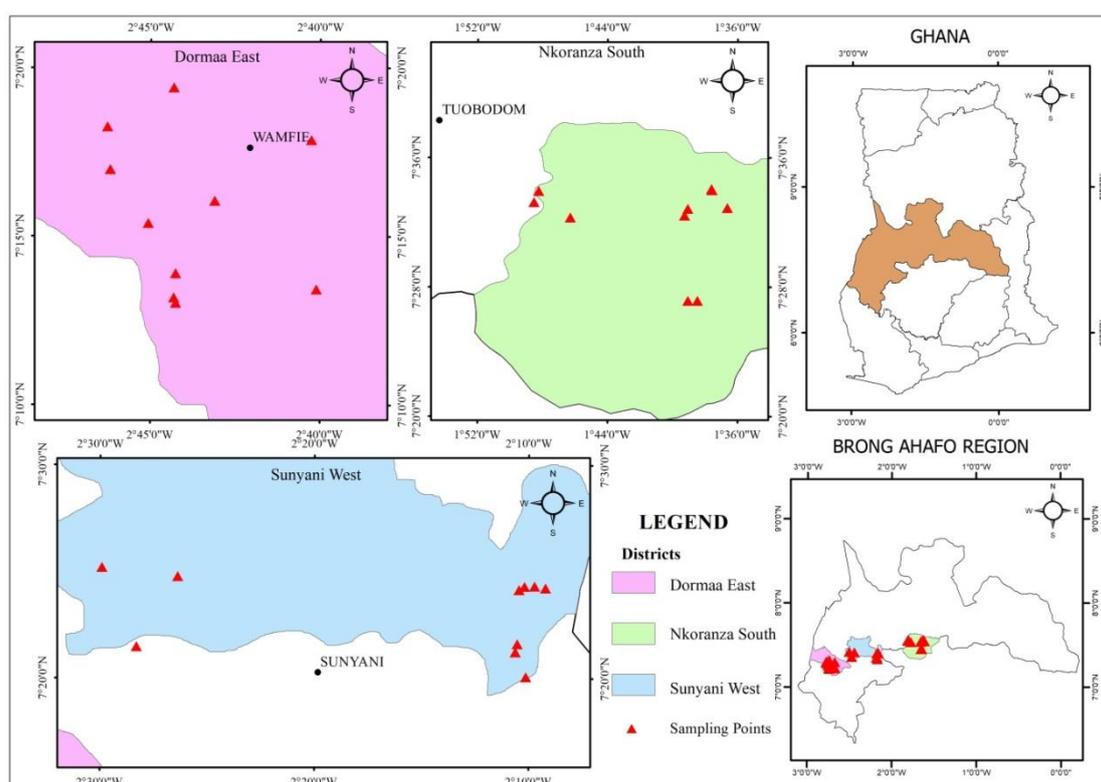


Figure 2. Location map of the three districts of the study area.

The study was conducted in the Dormaa East ($7^{\circ}08'N$ and $7^{\circ}25'N$; $2^{\circ}35'W$ and $2^{\circ}38'W$) and Sunyani West ($7^{\circ}19'N$ and $7^{\circ}35'N$; $2^{\circ}08'W$ and $2^{\circ}39'W$) districts and the Nkoranza South Municipality ($7^{\circ}20'N$ and $7^{\circ}55'N$; $1^{\circ}10'W$ and $1^{\circ}55'W$) of the Brong Ahafo Region in Ghana (Fig. II). These areas were selected based on reported cases of cassava root rot disease in the Brong- Ahafo region. The Dormaa East and Sunyani West districts are located in the Moist Semi-Forest zone and the Nkoranza

South Municipality lies in the Transition zone the main cassava producing agro-ecological zones in Ghana. The study areas experience semi-equatorial climatic conditions with mean monthly temperatures ranging from 23 °C to 38 °C, double maxima rainfall pattern from April to July and from September to November and an annual rainfall average ranging from 1300mm to 1700mm. The major occupation of most of the inhabitants of the three areas comes from agriculture (Ghana Statistical Service, 2014a; 2014b; 2014c).

2.2. Sampling of Cassava Fields for Cassava Root Rot Disease Infestation

Ten cassava fields with mature plants (aged ≥ 12 months) were randomly selected from communities with reported cases of cassava root diseases in each of the three districts; the Dormaa East, Sunyani West and Nkoranza South with the assistance of the District Agricultural Extension staff. The selected cassava fields were examined for cassava root rot disease infestation by sampling cassava plants in the two diagonal transects across each of the field visited. Cassava plants found at every one-metre distance along each of the two diagonal transect were uprooted and the roots examined for symptoms of root rot disease. Ten cassava fields with no disease symptoms of cassava root rot disease (non-infested fields) identified at the same locations as the disease infested fields in the various study areas were randomly selected as the control plots. Two treatments (infested and non-infested cassava fields) were tested in a randomized completely block design with five replications.

2.3. Soil Sampling and Analysis

Composite soil samples were taken from the selected arable fields at two different depths (0 – 20 cm and 20 – 40 cm) in the study area (Nkoranza South, Sunyani West and Dormaa East Districts). Both the cassava root rot infested and non-infested fields were sampled. Samples from the control plots served as the basis for comparison. The samples were properly bagged and labeled and were taken to the CSIR-Soil Research Institute laboratory for analysis.

These soil samples were analyzed for organic carbon, total nitrogen, available phosphorus, exchangeable calcium, magnesium, potassium and sodium, pH, Exchangeable acidity, Effective cation exchange capacity (ECEC) was determined by the sum of exchangeable bases (Ca^{2+} , Mg^{2+} , K^{+} and Na^{+}) and exchangeable acidity ($\text{Al}^{3+} + \text{H}^{+}$) and soil texture as described by Ibitoye (2006).

In this research nutrient level in the soils from cassava root rot infested fields were, compared with that from non-infested cassava fields using the FAO standard set by Motsara and Roy (2008).

2.4. Statistical Analysis

Data were analyzed using statistix 10.0. Analysis of variance (ANOVA) for nutrients was done by infested and non-infested cassava fields across districts. LDS was used to separate the means.

3. Results and Discussion

Results of the physico-chemical properties of soil samples taken from cassava root rot infested and non-infested cassava fields in the three districts (Dormaa East,

Sunyani West and Nkoranza South) in the Brong Ahafo Region (BAR) of the study area are presented in Table 1a and 1b.

Table 1a. Chemical properties of soil from infested and non-infested cassava fields in three districts of Brong Ahafo region of Ghana.

District	Treatment	pH	T N		O M	Avail. P	K	Ca	Mg	ECEC
			%							
Dormaa	Infested	6.12	0.13	2.42	4.45	1.59	5.61	2.43	10.29	
East	Non infested	6.32	0.13	2.37	3.04	2.29	6.31	2.37	11.75	
Nkoranza	Infested	6.75	0.04	0.73	3.69	0.50	3.34	1.10	5.35	
South	Non infested	6.85	0.05	0.77	3.53	0.72	4.06	1.29	6.51	
Sunyani	Infested	7.26	0.12	2.26	9.28	1.86	11.28	2.57	16.19	
West	Non infested	7.43	0.12	2.25	1.53	1.86	11.41	2.55	16.25	
Mean		6.85	0.10	1.73	4.57	1.43	7.13	2.01	11.08	
LSD		0.27	0.03	0.49	4.55	0.72	3.02	0.85	4.16	

The pH of soil samples ranged from 6.12 (Dormaa East infested) to 7.43 (Sunyani West non-infested) with a mean of 6.85 (Table 1a). This could be described as slightly acidic to slightly alkaline respectively (Motsara and Roy, 2008). According to O'Hair (1995) cassava can withstand a wide range of soil pH and has a stronger impact on the soil organic carbon.

The pH values were all within the pH range suitable for the cultivation of cassava. The mean pH values of the non-infested fields were found to be higher than those of the infested fields in all the three districts by a 0.15 mean pH unit (Table 1a). However, mean pH values for both the infested and non-infested fields in the Dormaa East district gave the lowest (slightly acidic) while Sunyani West gave the highest (slightly alkaline).

Cassava grows well in acid soils because of its tolerance to high levels of aluminum (Al) in soil solution. However, when the acidity is very high with high levels of exchangeable Al and/or low levels of calcium (Ca), Al toxicity affects growth of cassava (Bua and Okello, 2011).

Cassava plant require optimum growing medium to grow and produce maximally. Fertile soil is the optimum growing media and organic matter plays an important role in determining the fertility of Soil (Mehta et al., 2014). Thus, organic matter is an indicator of soil fertility and the higher the organic matter content the higher the fertility of the soil. Soil organic matter (SOM) ranged from 0.73 to 2.42% with a mean value of 1.73% (Table 1a). This is described as low (<1.50%) to moderate (1.5-3.0%) respectively (Motsara and Roy, 2008).

Generally the mean SOM values for Dormaa East and Sunyani West districts were moderate (2.25 – 2.42%), whilst the mean values for Nkoranza South were low for both the infested and non-infested cassava fields. To improve organic matter content particularly in the Nkoranza South district soil management practices such as cover cropping, soil and water conservation, application of organic manure (poultry manure, cow dung and compost) are required to promote accumulation of organic matter. The organic matter could control the disease severity by creating competition among microbial populations, antibiosis, hyper parasitism, systemic acquired resistance and induce systemic resistance, as well as make pathogen proliferation ineffective (Mehta et al., 2014).

In addition, the incorporation of organic matter into the soil may generate effect of volatile compounds that could kill or reduce the viability of fungal structures in the soil (Mehta et al., 2014).

The total nitrogen values followed the same trend as was observed in the soil organic matter ranging from 0.04 to 0.13% with mean value of 0.10% (Table 1a). This is considered as low (<0.10%) to moderate (0.1-0.20%) respectively (Motsara and Roy, 2008). Mean total nitrogen values for Dormaa East and Sunyani West districts were moderate (0.10 – 0.20%) whilst Nkoranza South were low. Generally there were no differences between the values obtained in the infested and the non-infested cassava field (LSD = 0.03).

Of all the nutrients that affect plant diseases and pests, potassium (K) is probably the most effective. As a mobile regulator of enzyme activity, K is involved in essentially all cellular functions that influence disease severity. Proper K nutrition has also been shown to help crops tolerate nematode infections with less yield loss (Hazelton and Murphy, 2007).

Exchangeable potassium values ranged from 0.5 (Nkoranza South infested) to 2.29 cmol (+) kg⁻¹ soil (Dormaa East non-infested) with a mean value of 1.43 cmol (+) kg⁻¹ soil (Table 1a). These are considered high (>0.40 cmol (+) kg⁻¹ soil) (Motsara and Roy, 2008). Over 90% of the samples had K values considered high and therefore K is adequate and would not require any K fertilizer.

Cassava extracts a considerable amount of K in the root harvest and long-term fertility research has revealed that sooner or later K deficiency becomes the most limiting nutrition factor if it is grown continuously without adequate K fertilization (Harper et al., 2004). Apparently all the cassava fields sampled had been cultivated with cassava continuous for not less than two. There were no differences between the values obtained in the infested and the non-infested cassava field (LSD = 0.72).

Calcium (Ca) forms part of the structural component of cell walls and other plant membranes (Harper et al., 2004). As such, it plays a major role in the integrity and function of these structures. Cell walls are not simply a barrier to infection, but when properly functioning, it regulates the passage of sugar and other compounds between cells and other plant parts. When Ca is low, it allows increased transport of sugars from within the cell to the intercellular spaces in the plant tissue. Higher sugar levels in these areas tend to increase the chances of infection and growth of disease pathogens (Harper et al., 2004).

Exchangeable calcium levels are directly related to soil pH levels. The exchangeable calcium ranged from 3.34 to 11.41 cmol (+) kg⁻¹ soil with a mean value of 7.13 cmol (+) kg⁻¹ soil (Table 1a). This is described as low (<5.0 cmol (+) kg⁻¹ soil) to high (>10.0 cmol (+) kg⁻¹ soil) respectively (Motsara and Roy, 2008). Nkoranza South had low exchangeable calcium, Dormaa East had moderate exchangeable Ca (5 - 10 cmol(+))kg⁻¹ soil) and Sunyani West had high exchangeable Ca.

Effective cation exchange capacity (ECEC) is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants (Hazelton and Murphy, 2007). Soil organic matter and clay content contribute significantly to the ECEC levels of soils. Thus, with high levels soil organic matter and clay contents, ECEC is expected to be high. ECEC values ranged from 5.35 cmol(+))kg⁻¹ soil in Dormaa East infested field to 16.25

cmol(+)kg⁻¹ soil in Sunyani West infested field with a mean value of 11.08 cmol(+)kg⁻¹ soil (Table 1a).

Generally, mean ECEC values for both the cassava root rot disease infested and non-infested fields were moderate (10 – 20 cmol(+)kg⁻¹ soil) in the Dormaa East and Sunyani West districts whilst Nkoranza South values were low (<10 cmol(+)kg⁻¹ soil). To improve ECEC of the soils management practices that improves soil organic matter content like organic manure application (cow dung, compost, poultry manure etc.) mulching, leguminous cover cropping and improved fallows are recommended.

Texture of the soil samples from cassava root rot disease infested and non-infested fields in Dormaa East and Sunyani West districts were sandy loam with Nkoranza South district soils being loamy sand (Table 1b). These are considered as light textured soils and are usually low in plant nutrients and lose water quickly. To boost the water and nutrient holding capacity of these soils, addition of organic matter is recommended particularly in the Nkoranza South district.

Table 1b. Physical properties of soil from infested and non-infested cassava fields in three districts of Brong Ahafo region of Ghana.

District	Treatment	Sand	Silt	Clay	Texture
		%			
Dormaa East	Infested	56.33	30.67	13.00	Sandy Loam
	Non infested	56.25	31.75	12.00	Sandy Loam
Nkoranza South	Infested	82.20	11.40	6.40	Loamy Sand
	Non infested	78.40	18.00	3.60	Loamy Sand
Sunyani West	Infested	67.83	23.83	8.33	Sandy Loam
	Non infested	70.25	19.00	10.75	Sandy Loam
Mean		69.81	21.67	8.52	
LSD		5.86	3.93	3.29	

4. Conclusions

Generally, the physico-chemical analyses show low to moderate levels of plant nutrients in the soil samples from cassava fields in the Dormaa East, Sunyani West and Nkoranza South districts of Brong Ahafo Region. Plant nutrients may be said to have been depleted and to increase cassava yields the major plant nutrients i.e. nitrogen, phosphorus and potassium should be increased by applying chemical fertilizers (urea, triple super phosphate and muriate of potash) and also management practices that improve soil organic matter content such as the manure application (cow dung, compost, poultry manure etc.) mulching, leguminous cover cropping and improved fallows should be given preference. There were no differences in terms of the physico-chemical properties of the cassava root rot disease infested and non-infested fields. This indicates that the presence or lack of plant nutrients may not necessarily be the cause of the cassava root rots disease though a fertile growing medium will produce a healthy cassava plant. It is therefore recommended that agricultural practices and environmental conditions that promote the cassava root rot disease should be avoided. Cassava should therefore be harvested within a reasonable harvesting time i.e. within 8 to 12 months after planting depending on the variety. Waterlogged areas must also be avoided, thus, well drained soils are preferred. Good farm sanitation practices such as collecting plant debris and burning after harvesting

and conducting regular field inspection to remove and destroy plants showing disease symptoms by burning should be strictly adhered to.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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