Nutritional quality response of sweet potato to different rates of organic and inorganic fertilizers

Abstract

A field experiment was conducted at the Crops Research Institute (CRI) at Fumesua – Kumasi from August to December, 2014. The research aimed at determining the root quality responses of sweet potato (*Ipomoea batatas L*) to organic manure (poultry manure and cow dung) and inorganic fertilizer (NPK, 15-15-15) and their combinations. The experiment was a 2*3 factorial with treatments arranged in randomized complete block design (RCBD) with three replicates. The treatments were: sole poultry manure (6t/ha); sole cow dung (8t/ha); sole NPK30-30-30; NPK, 15-15-15 + PM (3t/ha); NPK, 15-15-15 + CD (4t/ha); NPK, 22.5-22.5-22.5 + PM (1.5t/ha); NPK, 22.5-22.5-22.5 + CD (2t/ha); NPK, 7.5-7.5-7.5 +PM (4.5t/ha); NPK, 7.5-7.5-7.5 + CD (6t/ha); and no fertilizer amendment (control). The effect of organic manure, inorganic fertilizer and combination of two on the roots of sweet potato were studied the field condition.Two sweet potato varieties were used for the experiment. These were 'Apomuden' and 'Santom Pona'. The result indicated that on the average, NPK 15-15-15 + CD (4t/ha); NPK 15-15-15 + PM (3t/ha); and NPK 7.5-7.5-7.5 + CD (6t/ha) produced the highest responses (32.6%, 31.1%, and 30.9%) respectively to root dry matter content. NPK 22.5-22.5-22.5 +CD (2t/ha); sole poultry manure (6t/ha), and NPK 15-15-15 + CD (4t/ha) recorded the greatest protein content (6.1% each). Integrated application of organic manure and inorganic fertilizers (NPK, 15-15-15) is recommended for improved sweet potato production.

Key Words: Sweet potato, organic manure, inorganic fertilizers, roots

INTRODUCTION

Sweet potato is believed to have originated from Central America or North Western South America (Onwueme, 1978). Sweet potato, once mostly a directly consumed food crop, now has a diversified market. It serves as an important staple food for small-holder farmers. The vines, leaves and roots serve as feed for livestock (Yen, 1974). In other countries such as Japan and China, the crop has been put into multiple uses such as animal feed as well as industrial processing of the roots into starch and alcohol. In the savannah regions of Ghana, sweet potato is eaten in different forms such as ampesi, fried chips or can be boiled and mashed (Doku and Banful, 1993). Inorganic fertilizer has been the conventional method of soil mineral input. But these fertilizers are becoming increasingly expensive. Sole application of organic manure is often non-feasible due to limited availability and bulkiness where available. It is generally accepted that applying both organic and inorganic inputs is crucial in increasing crop production in West African (Palm et al., 1997). A number of studies carried out on organic and inorganic fertilizer combinations in sweet potato production have attested to a positive interaction between the two when applied at the same time (Palm et al., 1997). The application of N, P, K and S fertilizers generally increases nutritional quality of crops (Zhao-Hui et al., 2008). There have been reported increase in protein content of spring wheat when N was applied (Gauer et al., 1992). Wang et al., (2004) observed improvement in nutritional qualities in rice due to combined application organic and inorganic fertilizers. Fertilization is very effective in improving the nutritional quality of crops (Zhao-Hui et al., 2008). In Ghana, there is very little information on the appropriate combination rates of organic and inorganic fertilizer for sweet potato production (Dapaah et al., 2004). There is the need to assess the response of sweet potato to both organic and inorganic fertilizers, as well as in an integrated management system and how these affect quality factors of the roots. This will provide farmers with alternative ways of fertilization and also provide consumers with the nutritional values of sweet potato.

The main objective of the research was to determine the impact of an integrated application of organic and inorganic fertilizers on the root qualities of sweet potato for improved production.

MATERIALS AND METHODS

The research was carried out at the Crops Research Institute (CRI) at Fumesua-Kumasi from August to December, 2017. Fumesua is in the transitional agro-ecological zone of Ghana. The area has a bimodal rainfall pattern with the major season rains around April to June and the minor season rains from August to November. The annual rainfall for the area is 1,345mm per annum. The area usually has a temperature between 22^{o}C to 30^{o}C. The vegetation is that of humid forest type. The soil is that of Ferric Acrisol Asuansi Series type (Adu and Asiamah, 1992). The experiment was 2x3 factorial with treatments arranged in Randomized Complete Block Design (RCBD) with four replications. The fertilizer treatments studied were: 1. Poultry manure (6t/ha) 2. Cow dung (8t/ha) 3. NPK, 30-30-30 4. NPK, 15-15-15 + poultry manure (3t/ha) 5. NPK, 15-15-15 + cow dung (4t/ha) 6. NPK, 22.5-22.5-22.5 + poultry manure (1.5t/ha) 7. NPK, 22.5-22.5-22.5 + cow dung (2t/ha) 8. NPK, 7.5-7.5-7.5 + poultry manure (4.5t/ha) 9. NPK, 7.5-7.5-7.5 + cow dung (6t/ha) 10. No fertilizer amendment. Two sweet potato varieties, ‘Apomuden’ and ‘Santom Pona’ were used for the experiment. ‘Apomuden’ was released by the Crops Research Institute in 2005, while ‘Santom Pona’ was released in 1998. Vines with at least four (4) nodes were planted with at least two nodes buried in the soil. The vines were planted at 30 cm spacing on ridges. The organic fertilizers were applied and worked into the ridges two weeks before planting while the NPK was applied two weeks after planting.

Samples of the roots from each plot were taken to the laboratory for analysis. Yield quality factors such as beta carotene, dry matter content, zinc, iron, and crude protein, and sugar and starch contents of the roots were analysed using the Near-Infrared Reflectance Spectrophotometer (NIRS) computer. The root cracks, weevil attack and millipede attack were measured by visual observation of the roots and severity was measured on a scale of 1 – 5.

Data Analysis

Data collected was analysed using the analysis of variance (ANOVA) procedure to determine the differences in parameters using the SAS statistical package (SAS, 2011). The significantly different means were separated using the Least Significant Difference (LSD) at 5% significant level ($P < 0.05$).

RESULTS AND DISCUSSION

Physical and chemical properties of soil, poultry manure and cow dung

Table 1 indicates the physical and chemical properties of the poultry manure and cow dung samples. The total organic carbon, total nitrogen and exchangeable potassium of the soil samples were 2.26%, 0.13%, and 0.38 cmol/kg respectively while available phosphorus was 4.96 mg/kg. The pH of the soil was 6.8, with the texture being sandy loam. The properties of the poultry manure were found as follows: organic carbon was 25.24%, calcium of 3.22%, total nitrogen of 2.38%, potassium as 3.11 cmol/kg, available phosphorus was 1.08mg/kg and a pH of 7.61. It also had a sodium and magnesium contents of 0.22% and 4.60% respectively. With regards to the cow dung, the total organic carbon was found to be 11.27%, total nitrogen was 1.26%, the exchangeable potassium as 0.23 cmol/kg, that of available phosphorus to be 0.17 mg/kg and a pH of 7.2.

Table 1. Physical and chemical properties of soil, poultry manure and cow dung

Physical Properties	Soil (0-15 Cm)	Poultry Manure	Cow Dung
Organic carbon (%)	2.26	25.24	11.27

Calcium (%)	-	3.22	0.45
Total nitrogen (%)	0.13	2.38	1.26
Potassium (k) (Cmol/kg)	0.38	3.11	0.23
Available phosphorus (p) (mg/kg)	4.96	1.08	0.17
pH	6.9	7.61	7.2
Soil texture	sandy loam	-	-
Magnesium (%)	-	4.70	0.18

Weevil attack, root dry matter and weight of sweet potatoes

The results indicated that weevil attack on 'Apomuden' were significantly higher than 'Santom Pona'. This might be due to the higher contents of sucrose, beta-carotene and other minerals in 'Apomuden', coupled with its higher moisture content. These make 'Apomuden' sweeter and preferred by the weevils.

There were no significant differences among the fertilizer treatments with respect to the levels of attacks by weevils. This might be due to the fact that various fertilizer amendments did not significantly alter the taste and texture of storage roots of sweet potatoes. 'Santom Pona' variety showed significant difference as compared with 'Apomuden' in terms of dry matter content of the roots. Data from the Crops Research Institute of Ghana indicates 'Santom Pona' has a dry matter content of 34.4% while 'Apomuden' has a dry matter content of 21.9%.

On response to fertilizer type, NPK (15-15-15) + cow dung (4t/ha), NPK (15-15-15) + poultry manure (3t/ha), and NPK (7.5-7.5-7.5) + cow dung (4t/ha), produced the greatest responses. The least response to dry matter production was given by NPK (22.5-22.5-22.5) + poultry manure (1.5t /ha), NPK (7.5-7.5-7.5) + poultry manure (4.5t/ha) and poultry manure only. This observation is similar to Yeng et al. (2012), who stated that cow dung amended treatments produced higher dry matter contents. Somanath and Syeenivasmuthy (2005) also reported improved dry matter yield in

Coleus forskohlii due to integrated use of farmyard manure with NPK. The dry weight followed the pattern of responses by the matter.

Table 2. Effects of variety and fertilizer type on weevil attack, root dry matter and starch content of dry matter

Treatment	Weevil damage	Dry root matter (%)	Starch content (%) of dry matter
Variety			
Apomuden	3.1	24.9	46.8
Santom pona	1.3	36.7	66.6
LSD (5%)	0.5	1.2	1.4
Fertilizer Type			
Poultry Manure 6t/ha	2.3	30.1	56.5
Cow dung 8t/ha	2.3	29.9	55.8
200kg/ha NPK (15:15:15)	2.5	29.8	55.6
100 kg/ha NPK + PM3t/ha	2.2	31.1	57.9
100 kg/ha NPK + CD4t/ha	2.3	32.6	59.2
150 kg/ha NPK + PM1.5t /ha	2.2	29.7	55.5
150 kg/ha NPK + CD2t /ha	2.5	30.7	57.5
50 kg/ha NPK + PM4.5t /ha	1.7	29.8	54.9
50 kg/ha NPK + CD6t /ha	2.2	30.9	56.7
Control	2.0	30.9	57.6
LSD (5%)	NS	2.6	3.2
CV (%)	31.4	7.4	4.8

Other quality factors

The two varieties showed no significant differences for protein content, though 'Santom Pona' gave relatively higher value for protein content than 'Apomuden'. On fertilizer responses, NPK (22.5-22.5-22.5) + cow dung (2t/ha), poultry manure only, and NPK (15-15-15) + cow dung (4t/ha) produced the greatest protein content. Cow dung only and the control produced the least values for protein content. Granstedt and Kjellenberg (1997) observed higher quality protein in organic treatments. The relatively lower protein content in the sole cow dung amended soil might be as a result of the slow release of nutrients. Eghball and Power (1999), found that about 40% cattle manure become plant available in the first year after application.

‘Santom Pona’ variety recorded significantly greater value for starch content than ‘Apomuden’. With regard to response to fertilizer type, cow dung applied in combination with NPK (15-15-15) produced the highest responses. These higher responses might have been induced by the organic manure (1.5t/ha). Grandstedt and Kjellenberg (1997) reported that organic treatment produced higher starch content than inorganic fertilizers.

‘Apomuden’ variety contained greater fructose and glucose contents than ‘Santom Pona’. On responses to fertilizer types, cow dung only produced the greatest response for both glucose content and fructose content. Grandstedt and Kjellenberg (1997) observed that by organic fertilizer, the quality of fruit is improved, which is indicated by high concentrations of sugars and vitamins. Suge et al. (2011) reported that organic manure significantly enhanced fruit quality of plants. The control produced better response than all the other amended treatments. This indicates that poultry manure and NPK (15-15-15) led to reduction of glucose and fructose contents of sweet potatoes.

The results indicated that ‘Apomuden’ produced significantly higher than ‘Santom Pona’ in terms of iron content. With regards to fertilizer types, all the soils amended with fertilizer produced better responses than the soil without amendment (the control).

Table 3. Effect of variety and fertilizer type on quality factors of sweet potatoes

Treatment	Protein content (%) of dry matter	Fructose content (%) of dry matter	B-Carotene (%) Of apomuden
<u>Variety</u>			
‘Apomuden’	5.5	3.3	
‘Santom pona’	5.9	1.7	
LSD (5%)	NS	0.3	

Fertilizer Type			
Poultry Manure 6t/ha	6.1	2.3	29.5
Cow dung 8t/ha	4.8	2.9	31.3
200kg/ha NPK (15:15:15)	5.3	2.4	32.9
100 kg/ha NPK + PM3t/ha	5.8	2.1	29.1
100 kg/ha NPK + CD4t/ha	6.1	2.3	27.2
150 kg/ha NPK + PM1.5t /ha	5.8	2.5	30.0
150 kg/ha NPK + CD2t /ha	6.1	2.5	29.5
50 kg/ha NPK + PM4.5t /ha	5.9	2.7	30.8
50 kg/ha NPK + CD6t /ha	5.8	2.6	28.4
Control	5.2	2.8	30.7
LSD (5%)	1.0	0.7	3.9
CV (%)	15.7	24.5	7.8

Table 4. Effect of variety and fertilizer type on quality factors of sweet potatoes

Treatment	Glucose content (%) dry matter	Sucrose content (%) of dry matter
Variety		
Apomuden	4.6	20.9
Santom pona	2.3	6.1
LSD (5%)	0.5	1.1
Fertilizer Type		
Poultry Manure 6t/ha	3.1	14.0
Cow dung 8t/ha	4.1	14.1
200kg/ha NPK (15:15:15)	3.4	14.2
100 kg/ha NPK + PM3t/ha	2.8	12.7
100 kg/ha NPK + CD4t/ha	3.1	11.8
150 kg/ha NPK + PM1.5t /ha	3.5	14.4
150 kg/ha NPK + CD2t /ha	3.5	13.0
50 kg/ha NPK + PM4.5t /ha	3.8	14.9
50 kg/ha NPK + CD6t /ha	3.5	13.0
Control	3.8	12.6

LSD (5%) CV (%)	1.0 25.0	2.4 15.1

CONCLUSION:

Generally, with the exception of glucose and fructose contents, the combination of organic and inorganic fertilizers enhanced all the other root qualities of sweet potatoes.

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