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Growth and Yield Characteristics of Two Sweet Potato (*Ipomoea batatas L.*) Varieties as Influenced by Organic and Inorganic Fertilizer Application

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at the Crops Research Institute (CRI) at Fumesua – Kumasi from August to December, 2017. The research was to investigate the growth and yield characteristics of sweet potato (*Ipomoea batatas L*) to the application of organic manure (poultry manure and cow dung) and inorganic fertilizer (NPK, 15-15-15, 300kg/ha) and their combinations. The experiment was a 2x3 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 NPK45-45-45kg/ha; NPK, 22.5-22.5-22.5kg/ha + Poultry manure (PM) (3t/ha); NPK, 22.5-22.5-22.5kg/ha + Cow dung(CD) (4t/ha); NPK, 33.75-33.75-33.75kg/ha + PM (1.5t/ha); NPK, 33.75-33.75-33.75kg/ha + CD (2t/ha); NPK, 7.5-7.5-7.5kg/ha +PM (4.5t/ha); NPK, 7.5-7.5-7.5kg/ha + CD (6t/ha); and no fertilizer amendment (control). Two sweet potato varieties, 'Apomuden' and 'Santom Pona' were used. The results indicated that on the average, the organic manure and the inorganic fertilizer combinations promoted greater growth than the sole applications and the control. The

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greatest marketable root yield (14.8 t/ha) obtained from 7.5-7.5-7.5 NPK + 4.5 t/ha PM. For root dry matter, NPK 22.5-22.5-22.5 + CD (4t/ha); NPK 22.5-22.5-22.5 + PM (3t/ha); and NPK 7.5-7.5-7.5 + CD (6t/ha) produced the greatest responses (32.6%, 31.1%, and 30.9%) respectively. Integrated application of organic manure and inorganic fertilizers is thus recommended for improved sweet potato production.

Keywords: Sweet potato; organic manure; inorganic fertilizers; integrated application; yield.

1. INTRODUCTION

Sweet potato is believed to have originated from Central America or North Western South America [1]. Sweet potato 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. 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 [2]. In Ghana, sweet potato is the fourth most important root crop. The crop is widely cultivated in the Northern, Upper East, Upper West Savannah, Central and Volta Regions of Ghana by smallholder farmers [3]. Annual production of sweet potato in Ghana is estimated at 0.132 million tonnes produced on approximately 9,622 hectares of arable land [4]. Low yield of around 8t/ha compared to the potential yield of around 24t/ha are recorded. Until now, the vast majority of sweet potato cultivated in Ghana were low yielding white-fleshed cultivars which have no or low beta-carotene. However, the Root and Tuber Improvement and Marketing Programme and other partners such as the Crop Research Institute have made tremendous strides in introducing improved and high yielding cultivars such as CRI-Santom Pona, CRI-Legri, CRI-Apomuden - which is rich in Beta carotene [5], Faara, CRI-Bohye, CRI-Dadanyuie, Okumkom and Sauti [6].

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 are crucial in increasing crop production in West African [7]. 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 [7]. It has been reported that sweet potato gives a positive response to varying regimes of nitrogen, phosphorus and potassium fertilizers [8]. Poultry manure in combination with inorganic fertilizer is reported to give significant marketable root yield in sweet potato [9]. Yeng et al., [10] observed that organic and inorganic inputs combination for soil mineral supplementation in sweet potato production is a better option than either of organic and inorganic inputs applied solely. In Ghana, there is very little information on the appropriate combination rates of organic and inorganic fertilizer for sweet potato production [8]. 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 growth and yield of sweet potato. This will provide farmers with alternative ways of fertilization.

Considering the ever-increasing cost of the chemical fertilizers and its potential attendant environmental effects, a research to find alternative ways of providing nutrients for the growth and yield of sweet potato is worth undertaking.

The objective of the research was to determine the impact of an integrated application of organic and inorganic fertilizers on the growth and yield characteristics of sweet potato for improved production.

2. 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 [11]. 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, 45-45-45kg/ha 4. NPK, 22.5-22.5-22.7kg/ha + poultry manure (3t/ha) 5. NPK, 22.5-22.5-22.5kg/ha + 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. 'Santom Pona' on the other hand was released in 1998 by the same institute. 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 (by mixing with the soil) two weeks before planting while the NPK was applied two weeks after planting by side dressing.

Growth and yield parameters measured were plant establishment, vine length, number of plants harvested, number and weight of marketable roots, number and weight of non-marketable roots, fresh vine yield, roots cracks, weevil attack and millipede attack [12]. Plant establishment was measured by counting the number of vines that sprouted from the two central rows of each plot, three weeks after planting (WAP). The vine length was taken by measuring the main vine of the selected plants from the base to the tip, using a tape measure (three months after planting). The number and weight of marketable and non-marketable roots were determined by measuring the root diameter from the middle portion of the root using the Veneer calipers. Roots with diameter of 5cm and above were considered marketable roots. Roots with diameter of less than 5cm as well as those which were badly damaged by weevils were considered non-marketable. Fresh vine yield was taken by bulking all the vegetative parts above the ground of the plants harvested per plot and measuring their weight on a scale.

2.1 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 ($P < 0.05$).

3. RESULTS AND DISCUSSION

3.1 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

3.2 Percentage Plant Establishment and Vine Length

There was no significant difference between the two varieties in respect of plant establishment. The optimum sprouting of the vines might be attributed to the fact that the planting materials were taken from fresh and actively dividing portions of the vines. Dapaah et al. [8], Yeng et al. [10] and CIP [13] have observed that planting materials from healthy and vigorously growing vines as well as optimum planting depth, spacing and good land preparation ensure good sprouting of vines. Adequate supply of water could also be a contributory factor to the high percentage plant establishment.

There was no significant difference between 'Apomuden' and 'Santom Pona' in vine length. However, 'Apomuden' recorded greater value for vine length than 'Santom Pona'. On responses to fertilizer type, the effects of poultry manure (6t/ha) only, NPK 22.5-22.5-22.5 + Pm (3t/ha), NPK 22.5-22.5-22.5 + CD (4t/ha), NPK 7.5-7.5-7.5 + PM (4.5t/ha) treatments were all significantly higher than that of the NPK 22.5-22.5-22.5 + Cow dung (2t/ha) treatment only. All other treatment differences were not significant (P > 0.05). Cheng-Wei et al. [14], Ouda and Mahadeen [15] stated that combined application of organic and inorganic fertilizers results in the vigorous vegetative growth of plants. Teshome et al. [16] also reported that interactive effect of organic manure and inorganic fertilizers highly influenced vine length and plant height. Again, Bwembya and Yerokum (2001) reported that plants treated with inorganic fertilizers and manure were significantly taller than those that received either of the treatments. Deshmiskh et al. [17] indicated that the appropriate ratio of organic and inorganic fertilizers in the field act as growth promoters for crops. The release of nutrients from chemical fertilizers is very fast, after which there is a slow release of nutrients from the organic fertilizers. This ensures continuous supply of nutrients to the plants. This might account for the organic and inorganic fertilizer combinations performing better than the sole application.

3.3 Fresh Vine Yield, Weight of Marketable and Non-marketable Roots

From the results, the fresh vine yield of 'Santom Pona' was significantly higher than 'Apomuden'. This is a characteristic of 'Santom Pona' as it produces large amount of foliage. The effect of the various fertilizers on fresh vine yield indicated that NPK (7.5-7.5-7.5) + poultry manure (4.5t/ha) and NPK (22.5-22.5-22.5) + poultry manure (1.5t/ha) were significantly higher than the other treatments. Many researchers have indicated that organic and inorganic amendments significantly increase the vegetative growth of plants [18,14,15,19]. All the amended treatments, but cow dung only produced higher responses than the control. This might probably be due to augmentation of the nutrients in the soil by the fertilizers.

Table 2. Effects of variety and fertilizer type on plant establishment and vine length

Treatment	Plant Establishment (Number)	Vine Length (cm)
Variety		
Apomuden	18.0	202.0
Santom pona	18.3	186.1
LSD (5%)	NS	NS
Fertilizer Type		
Poultry Manure	18.3	204.7a
Cow dung only	18.5	182.5ab
200 NPK	17.8	186.7ab
100 NPK + 3t PM	18.8	213.2a
100 NPK + 4t CD	18.7	215.2a
150 NPK + 1.5t PM	17.8	196.2ab
150 NPK + 2t CD	17.8	160.2b
50 NPK + 4.5t PM	18.0	208.3a
50 NPK + 6t CD	18.5	186.0ab
Control	17.8	186.7ab
LSD (5%)	NS	40.7
CV (%)	4.9	18.0

Table 3. Effects of variety and fertilizer type on fresh vine yield, marketable and non – marketable roots

Treatment	Fresh Vine Yield (t/ha)	Weight Marketable Roots (t/ha)	Weight Non-Marketable Roots (t/ha)
Variety			
Apomuden	7.3b	12.2a	4.2a
Santom pona	11.7a	9.2b	2.6b
LSD (5%)	1.8	2.2	1.1
Fertilizer Type			
Poultry Manure 6t/ha	9.4bc	11.8ab	3.8ab
Cow dung 8t/ha	8.7bc	8.5bc	3.7ab
200kg/ha NPK (15:15:15)	7.4c	8.3bc	2.2b
100 kg/ha NPK + PM3t/ha	10.3ab	13.3ab	4.8a
100 kg/ha NPK + CD4t/ha	8.5c	10.4abc	2.7b
150 kg/ha NPK + PM1.5t /ha	12.6ab	12.0abc	3.6ab
150 kg/ha NPK + CD2t /ha	8.3c	7.5c	3.0ab
50 kg/ha NPK + PM4.5t /ha	13.7a	14.8a	3.5ab
50 kg/ha NPK + CD6t /ha	9.1bc	11.2abc	3.8ab
Control	7.3c	7.9c	2.7b
LSD (5%)	4.0	5.0	2.4
CV (%)	21.8	19.9	22.0

The results of the research indicated that 'Apomuden' produced greater number of marketable roots as compared with 'Santom Pona'. This results confirm the characteristics of the two varieties of sweet potatoes, which gives 'Apomuden' greater yield (about 30t/ha) than 'Santom Pona' (about 17t/ha). Poultry manure only treatment produced the greatest value for the number of marketable roots. This supports a report by Parraga et al. [18] that poultry droppings produced the maximum root diameter. Ouda and Mahadeen (2005) and Suge et al. [20] observed that organic manure significantly enhanced the yield of plants.

The greatest response to marketable root weight was produced by NPK (7.5-7.5-7.5) + poultry manure (4.5t/ha). Parraga et al. [18] also found out that application of organic matter with NPK fertilizer increased the root diameter. Tolessa and Friesien (2001) also reported that the application of 25% recommended inorganic N and P fertilizers with enriched farmyard manure resulted in higher marginal rates of returns in maize. In 2022, Nyarko et al. [21] observed improvement in the root qualities of sweet potato due to combined application of organic and inorganic fertilizers.

4. CONCLUSION

The results of the research indicated that sweet potato growth responds better to an integrated application of organic manure and inorganic fertilizers than sole application of either of the two.

Application of poultry manure (6t/ha) as sole application produced the greatest marketable roots, while NPK,15-15-15(7.5-7.5-7.5) + poultry manure (4.5t/ha) produced the greatest marketable root weight and fresh vine yield in sweet potatoes.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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