

BULKING AND YIELD OF CASSAVA (*Manihot esculenta* Crantz) FOLLOWING APPLICATION OF ORGANIC AND INORGANIC FERTILIZERS

Keywords: cassava, fertilizer, bulking, and yield

Abstract

The research was conducted at Namong Senior High Technical School in the Offinso Municipality in the Ashanti Region of Ghana to determine bulking and yield of cassava following application of organic and inorganic fertilizer. The experimental design for the research was a 2 x 6 factorial arranged in a Randomized Complete Block Design (RCBD) with three replications. The treatments comprised two cassava varieties (Bankyehemaa and Nkabom) and six fertilizer types (F1: Control -No fertilizer application, F2: 600kg/ha NPK 15:15:15, F3: 600kg/ha NPK 23:10:10, F4: 2t/ha poultry manure (PM), F5: 1t/ha PM + 300kg/ha NPK 15:15:15 and F6: 1t/ha PM + 300kg/ha NPK 23:10:10). Normal husbandry practices including refilling, application of fertilizer, control of pests and diseases and weeding were undertaken. The results of the study showed that yield and yield components except tuber length were significantly affected by variety with Bankyehemaa variety producing greater effect in most of the yield parameters. The fertilizer-applied treatments produced greater yield and yield components over the control treatment. The complementary application of poultry manure and NPK 23:10:10 treatment significantly produced the greatest fresh tuber yield of 123.60 t/ha and was superior in almost all yield attributes.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a short-day, dicotyledonous perennial woody shrub of the *Euphorbiaceae* or *Tuphorbiallae* family. According to Nweke *et al.* (1994), it is believed to have been introduced into Africa by the Portuguese from Latin America in the 16th century.

Global production of cassava was 252 million tonnes in 2011 of which over 140 million tonnes were from Africa (FAOSTAT, 2011). The world's leading cassava producer, Nigeria, produced over 42 million tonnes in 2011 (FAOSTAT, 2011), while Ghana produced 14.2 million tonnes and was ranked second in production in West Africa. In Ghana, cassava is a staple and an export crop and contributes 22% to the Agricultural Gross Domestic Product (MoFA, 2011), with per capita consumption of 152.9 kg/year (MoFA, 2009).

Safo *et al.* (1998) noted that, for most crops, the best fertilizer types, rates and time of application are not known and that this constitutes a major constraint to fertilizer use in the country. They also indicated that mineral fertilizers are scarcely used because of their prohibitive high prices. The effect of poultry manure on performance and nutrient composition of cassava and its suitable rate has not received adequate research attention. The main objective was, therefore, to study the effects of NPK fertilizer, poultry manure and their combined application on growth, yield parameters and nutrient composition of cassava.

The specific objectives of this research were to determine:

- the effect of fertilizer application on tuber yield of cassava;
- the effect of fertilizer application on time of bulking (root initiation and tuberization) of cassava;
- effect of combined application of organic and inorganic fertilizer on cassava root yield.

MATERIALS AND METHODS

The research was conducted at Namong Senior High Technical School in the Offinso Municipality in the Ashanti Region of Ghana in 2014. The area falls within latitudes 6°45N and 7°25N and longitudes 1°65W and 1°45E at an elevation of 250m- 300m above sea level.

47 The experimental design was a 2 x 6 factorial with treatments arranged in a Randomized
48 Complete Block Design (RCBD) with three replications. There were thus twelve treatment
49 combinations.

50 The cassava varieties were Bankyehemaa (BH) and Nkabom (NB). The fertilizer treatments were
51 No fertilizer (F1), 600 kg/ha NPK15:15:15 (F2), 600 kg/ha NPK 23:10:10 (F3), 2 t/ha poultry
52 manure (F4), 1 t/ha PM + 300 kg/ha NPK 15:15:15 (F5) and 1 t/ha PM + 300 kg/ha NPK
53 23:10:10 (F6)

54 The planting materials consisted of mature stem cuttings (stakes) of about 20 cm in length,
55 containing between 10 and 12 nodes. These were planted in an angled position at a spacing of 1
56 m x 1 m on a flat-tilled land.

57 **Data Collected**

58 Data were collected at four months after planting and at an interval of two months till harvesting.
59 At each sampling period, four plants were sampled per plot and plant parameters were measured.
60 Four plants from an area covering 4m² were harvested per treatment and the fresh tuber weight
61 measured and then converted to kilograms (kg) per hectare and then to tonnes per hectare to
62 obtain the fresh tuber yield. The harvest index was calculated by dividing the dry root tuber
63 weight (economic yield) by the total dry biological yield. The diameter of the tubers per plant
64 was taken with vernier calipers and the average was calculated for each plot. Four plants were
65 harvested and the mean weight of the root tubers taken. The number of plants per m² for each
66 treatment was harvested and the root tubers were stripped and sun-dried to constant weight and
67 the dry weight measured. The storage root dry matter percentage was determined from a random
68 bulk sample of four plants selected from the two inner rows of each plot. Whole tubers were

69 shredded after brushing off soil from the tubers. Duplicate samples of 200 g each were dried at
70 70°C for 72 h (until constant weights) in a forced air-drying oven to estimate the dry weights.

71 **3.5. Data analysis**

72 Analysis of variance was used to analyse all data using the (GENSTAT, 2012) package. The
73 Least Significant Difference (LSD) at 5% probability was used to compare treatment means.

74

75 **RESULTS**

76 **Fresh tuber yield, Storage root dry matter and Harvest index**

77 Results of fresh tuber yield showed no significant effect ($P>0.05$) with variety, but application of
78 fertilizer had. Among the fertilizer treatments, the combined application of poultry manure and
79 NPK 23:10:10 resulted in the greatest fresh tuber yield, and this was significantly higher
80 ($P<0.05$) than all other treatment effects. The control treatment effect was significantly ($P<0.05$)
81 lower than all other fertilized treatment effects.

82 Significant ($P<0.05$) differences were observed in harvest index and storage root dry mater with
83 variety and application of fertilizer (Table 1). Bankyehemaa variety significantly ($P<0.05$)
84 produced greater storage root dry matter than Nkabom variety. The control (F1) produced the
85 lowest storage root dry matter, which was significantly lower than all other treatment means,
86 except that of NPK 15:15:15 only. The greatest value of storage root dry matter was produced in
87 the combined application of poultry manure and NPK 23:10:10.

88 Nkabom variety produced significantly ($P<0.05$) greater harvest index than Bankyehemaa
89 variety (Table 1). The combined application of poultry manure and NPK 23:10:10 (F6) recorded
90 the greatest harvest index which differed significantly ($P<0.05$) from the sole applications of
91 NPK 15:15:15 (F2) and NPK 23:10:10 (F3) only. All other treatment differences were not

significant ($P>0.05$).

Table 1. Effects of variety and application of organic and inorganic fertilizers on fresh tuber yield (t/ha), storage root dry matter and harvest index (HI) in 2014/2015 growing season

Sources	Fresh tuber yield (t/ha)	Storage root dry matter (%)	Harvest Index (HI)
<u>Variety</u>			
BH	107.50	34.47	0.57
NK	103.20	30.47	0.65
LSD (5%)	NS	1.30	0.03
<u>Fertilizer</u>			
F1	80.30	29.74	0.62
F2	113.90	31.16	0.57
F3	99.20	33.91	0.57
F4	107.70	32.50	0.64
F5	107.50	32.51	0.61
F6	123.60	35.01	0.66
LSD (5%)	9.47	2.26	0.05
Grand mean	105.40	32.47	0.61
CV (%)	7.50	5.80	7.30

Root weight

Root weight results are presented in Table 2. Results showed significant effect ($P<0.05$) with variety at 4 and 6 MAP only. Bankyehemaa variety significantly ($P<0.05$) produced greater root weight than Nkabom variety at 4 MAP, while Nkabom variety significantly ($P<0.05$) produced

greater root weight than Bankyehemaa variety at 6 MAP. Application of fertilizer significantly affected root weight on all sampling days. The control significantly ($P<0.05$) produced the lowest root weight on all sampling days, except at 4 MAP where the yield was similar to when poultry manure only and combined application of NPK 23:10:10 and poultry were applied. The greatest root weight was obtained in application of NPK 23:10:10, poultry manure, NPK 15:15:15 and combined application of NPK 23:10:10 and poultry manure (F6) at 4, 6, 8 and 11 MAP, respectively. At 4 MAP, application of NPK 23:10:10 (F3) produced the greatest root weight which significantly ($P<0.05$) differed from the other treatment means, except combined application of NPK 15:15:15 and poultry manure and NPK 15:15:15 treatments only. The greatest root weight was measured in the poultry manure treatment only at 6 MAP, which was significantly higher ($P<0.05$) than all other treatment effects. At 8 MAP, the NPK 15:15:15 only treatment was significantly higher ($P<0.05$) than all other treatment effects. The combined application of NPK 23:10:10 and poultry manure produced the greatest root weight at 11 MAP, and this was significantly higher ($P<0.05$) than all other treatment effects. On all these occasions, the control treatment effect was significantly ($P<0.05$) lower than all other treatment effects.

Table 2: Effects of variety and application of organic and inorganic fertilizers on fresh root weight per plant of cassava in different months of harvesting in 2014/2015 growing season

Sources	<u>Root weight</u> (kg plant ⁻¹) at			
	4 MAP	6 MAP	8 MAP	11 MAP
<u>Variety</u>				
BH	0.79	2.86	5.62	10.75
NK	0.57	3.51	6.53	10.32
LSD (5%)	0.16	0.28	NS	NS

159	<u>Fertilizer</u>				
160					
161	F1	0.38	0.93	1.68	8.03
162					
163	F2	0.76	4.16	9.54	11.39
164					
165	F3	1.02	3.14	6.18	9.92
166					
167	F4	0.53	4.96	7.00	10.76
168					
169	F5	0.81	2.75	4.60	10.75
170					
171	F6	0.57	3.16	7.44	12.36
172					
173	LSD (5%)	0.27	0.48	1.60	0.95
174					
175	Grand mean	0.68	3.19	6.07	10.54
176					
177	CV (%)	33.30	12.60	22.10	7.50
178					

179

180

181 **Tuber girth**

182 Significant ($P<0.05$) varietal differences were recorded only at 8 MAP with Bankyehemaa

183 producing a greater mean tuber girth than Nkabom variety. On the other sampling days, varietal

184 differences were not significant (Table 3). Application of fertilizer significantly ($P<0.05$)

185 influenced root tuber girth on all days of sampling. The sole application of NPK 15:15:15

186 produced the greatest mean tuber girth at 4 MAP, which was significantly higher than all other

187 treatment effects, except the combined application of NPK 23:10:10 and poultry manure. At 6

188 MAP, NPK 23:10:10 (F3) only and poultry manure (F4) only treatments produced similar

189 effects, and either effect was significantly higher than all other treatment effects, except

190 combined application of NPK 15:15:15 and poultry manure. At 8 MAP, tuber girth from NPK

191 15:15:15 only treatment was the greatest, which was significantly higher than all other treatment

192 effects, except that of NPK 23:10:10 (F3) only and poultry manure only treatments. At 11 MAP,

193 treatment effect of the combined application of NPK 23:10:10 and poultry manure was greater
194 than all other treatment effects, except that of NPK 15:15:15 only treatment. On all sampling
195 occasions, the control treatment effect was the lowest.

196 Table 3. Effects of variety and application of organic and inorganic fertilizers on mean root tuber
197 girth (mm) of cassava at different months of harvesting in 2014/2015 growing season
198

<u>Mean tuber girth</u> (mm) at				
Sources	4 MAP	6 MAP	8 MAP	11 MAP
<u>Variety</u>				
BH	17.47	31.95	39.22	50.68
NK	16.37	33.51	36.77	51.96
LSD (5%)	NS	NS	1.90	NS
<u>Fertilizer</u>				
F1	12.08	24.66	30.71	44.13
F2	20.39	33.04	42.12	55.30
F3	17.52	34.44	40.28	51.32
F4	15.61	38.04	40.51	51.42
F5	17.14	34.58	35.92	52.26
F6	18.80	31.60	38.43	53.51
LSD (5%)	2.83	5.04	3.29	5.96
Grand mean	16.92	32.73	37.99	51.32
CV (%)	14.00	12.90	7.20	9.70

5.0 DISCUSSION

Cassava variety did not significantly influence fresh tuber yield as indicated in Table 1. The minor variation in the yields between the two varieties could be genetic and this may be attributed to the differences in efficiency of partitioning of dry matter to the sinks (root tubers) and a much greater sink capacity of Bankyehemaa variety. The higher tuber yield obtained from the variety could be the result of production of greater number of tubers per plant and greater root weight per plant. Evangeline *et al.* (2002) indicated that an increase in cassava root yield could be due to the increase in the single root weight per stand. In a similar observation, Wholey and Cock (1974) reported that the number of roots and tuber growth are the main contributors to yield differences among cassava varieties.

The fertilizer-applied treatments resulted in greater fresh cassava tuber yield than the control treatment, and this is supported by Sarfo (2015) who recorded greater root yield when fertilizer was applied. Paula *et al.* (1983) reported that fertilizer application can increase root yield of cassava by 30%, while FAO (1999) reported increased crop yields of up to 49%. The combined application of NPK 23:10:10 and poultry manure resulted in the greatest fresh tuber yield as that treatment produced the greatest number of tubers per stand and tuber weight per plant. This is because combined fertilizer use is known to increase soil productivity and nutrient use efficiency (Santhi and Selvakumari, 2000) and increase synchrony and reduce losses by converting inorganic N into organic forms (Kramer *et al.*, 2002). The use of mineral fertilizer in combination with poultry manure has shown to increase yield as much as 60 t/ha of cassava roots (CSIR- AGRA, 2012). Lou *et al.* (2008) similarly reported that organic manure-biofertilizer-chemical fertilizer combination promoted cassava yields and starch content.

Results of Table 1 showed that the Bankyehemaa variety produced a greater storage root dry matter content of 34.47% than the Nkabom variety (30.47%), and this may be due to variation in their mean tuber weights. Adeniji *et al.* (2011) reported similar results that storage root dry matter content was significantly negatively correlated with storage root weight. The storage root dry matter content for the two cassava varieties studied were in agreement with the values reported by Chávez *et al.* (2005) who observed that the dry matter contents for cassava range from 10.7% to 57.2%, with an average of 34.7%. The combined application of NPK 23:10:10 and poultry manure significantly produced the greatest storage root dry matter (Table 1) presumably due to greater partitioning of assimilate and higher yield attributes.

The harvest indices of 0.65 and 0.57 for Nkabom and Bankyehemaa varieties, respectively were close to that reported by Baafi and Safo-Kantanka (2008) of 0.64 for Afisiafi and Abasafitaa varieties, but higher than that reported by Sarfo (2015) of 0.43 for Bankyehemaa variety. The indices in the present study were also in the range of 0.54-0.94 obtained by Ojeniyi *et al.* (2012). The harvest indices were generally high, exceeding 50% in all cases, indicating a fairly effective redistribution of photosynthates and conversion of assimilates from leaves and stems into the tubers. Significant differences in harvest index have been reported among cultivars, indicating that it can be used as a selection criterion for higher yield potential in cassava (Tavora *et al.*, 1995).

The fertilizer-treated plants produced greater tuber weight per plant than the control treatment (Table 1). The combined application of poultry manure and NPK 23:10:10 significantly produced greater tuber weight per plant. Organic manures reduce leaching and nutrients contained in them are released more steadily and slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect (Tisdale *et al.*, 1993). This could have encouraged

the production of more and heavier tubers per plant following good vegetative growth which translated into better production and transfer of photoassimilates.

Both varietal and fertilizer treatment effects for tuber girth were significant (Table 3). Nkabom variety produced a greater tuber girth (51.96 mm) than that of Bankyehemaa variety (50.68 mm) at harvest. The greater tuber girth in Nkabom variety may be ascribed to the fewer number of tubers per plant it produced leading to less intra-plant competition between roots during bulking. Again, that variety might be a more efficient plant in accumulating carbohydrates in storage roots. Work of Howeler *et al.* (1982) indicated that greater tuber girth resulted from lesser number of roots for storing the synthesized assimilates supports this assertion. Magoon *et al.* (1972) also found that the storage root size was inversely related to the number of tubers per plant and this is in corroboration with the findings of this trial.

The fertilizer-treated plants produced greater tuber girth than those of the control treatment, with NPK 15:15:15 only treatment having biggest root tuber than the other treatments. The results could be attributed to availability of nutrients, especially phosphorus and potassium which are essential for tuber growth. Ayoola and Makinde (2007) made a similar observation that application of fertilizer had a significant effect on tuber girth of cassava with NPK 15:15:15 only treatment producing the biggest tuber girth. Leo and Kabambe (2014) observed in their studies that the significant increase in diameter of roots has a positive correlation with fertilizer treatment.

Conclusion

The results of the study showed that yield and yield components except tuber length were significantly affected by variety with Bankyehemaa variety producing greater effect in most of

the yield parameters. The fertilizer-applied treatments produced greater yield and yield components over the control treatment. The combined application of poultry manure and NPK 23:10:10 treatment significantly produced the greatest fresh tuber yield and was superior in all yield attributes, except tuber girth which was maximized by NPK 15:15:15 alone treatment.

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