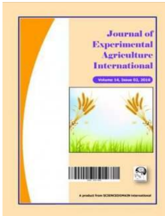

Journal of Experimental Agriculture International
15(1): 1-7, 2017; Article no.JEAI.29013
Previously known as American Journal of Experimental Agriculture
ISSN: 2231-0606

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Bulking and Yield of Cassava (*Manihot esculenta* Crantz) Following Application of Organic and Inorganic Fertilizers

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2017/29013
Editor(s):
(1) Christos Tsadilas, Hellenic Agricultural Organization-"DEMETER", Directorate General of Agricultural Research, Institute of Soil Mapping and Classification, Greece.
Reviewers:
(1) Isaac Kojo Arah, Ho Polytechnic, Ghana.
(2) Saraswati Prabawardani, The University of Papua, Manokwari, West Papua, Indonesia.
Complete Peer review History: http://www.sciencedomain.org/review-history/17395

Original Research Article

Received 17th August 2016
Accepted 28th September 2016
Published 30th December 2016

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 levels of variety (Bankyehemaa and Nkabom) and six levels of fertilizer types (F1: Control -No fertilizer application, F2: 600 kg/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 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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It was concluded that the fertilizer-applied treatments produced greater yield and yield components over the control treatment, while Bankyehemaa variety marginally outperformed the Nkabom variety in terms of tuber yield. It is recommended that in future research, treatments should be modified to study varietal responses to treatment application. Treatment modification should include application of different rates of NPK fertilizer at different times.

Keywords: Cassava; fertilizer; bulking; yield.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a short-day, dicotyledonous perennial woody shrub of the *Euphorbiaceae* or *Tuphorbiallae* family. According to [1], it is believed that cassava has 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 [2]. The world's leading cassava producer, Nigeria, generated over 42 million tonnes in 2011 [2], 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 [3], with per capita consumption of 152.9 kg/year [4].

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. Mineral fertilizers are scarcely used because of their prohibitive high prices [5]. The main objective was, therefore, to study the effects of NPK fertilizer, poultry manure and their combined application on yield and yield components of cassava.

2. 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 is located within latitudes 6'45N and 7'25N, longitudes 1°65W and 1°45E, and at an elevation of 250 m- 300 m above sea level.

The experimental design was a 2x6 factorial with treatments arranged in a Randomized Complete Block Design (RCBD) with three replications. There were thus twelve treatment combinations.

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

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

2.1 Data Collected

Data were collected at four months after planting and at an interval of two months till harvesting. At each sampling period, four plants were sampled per plot and plant parameters were measured.

Four plants from an area covering $4m^2$ were harvested per treatment and the fresh tuber weight measured and then converted to tonnes per hectare to obtain the fresh tuber yield. The harvest index was calculated by dividing the dry root tuber weight (economic yield) by the total dry biological yield. Diameter of tubers per plant was measured using vernier calipers and the average of tuber diameter was calculated for each plot. Four plants were harvested and the mean weight of the root tubers was calculated. The number of plants per m^2 for each treatment was harvested and the root tubers were stripped and sun-dried to constant weight and the dry weight was measured. The storage root dry matter percentage was determined from a random bulk sample of four plants selected from the two inner rows of each plot. Whole tubers were shredded after brushing off soil from the tubers. Duplicate samples of 200 g each were dried at 70°C until constant weights were obtained in a forced air-drying oven to estimate the dry weights.

2.2 Data Analysis

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

3. RESULTS

3.1 Fresh Tuber Yield, Storage Root Dry Matter and Harvest Index

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

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

Table 1. Effects of variety and application of organic and inorganic fertilizers on fresh tuber yield, 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)
Variety			
BH	107.50	34.47	0.57
NK	103.20	30.47	0.65
LSD (5%)	NS	1.30	0.03
Fertilizer			
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

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

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

Sources	4 MAP	6 MAP	8 MAP	11 MAP
Variety				
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
Fertilizer				
F1	0.38	0.93	1.68	8.03
F2	0.76	4.16	9.54	11.39
F3	1.02	3.14	6.18	9.92
F4	0.53	4.96	7.00	10.76
F5	0.81	2.75	4.60	10.75
F6	0.57	3.16	7.44	12.36
LSD (5%)	0.27	0.48	1.60	0.95
Grand mean	0.68	3.19	6.07	10.54
CV	33.30	12.60	22.10	7.50

3.2 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 produced greater root weight than Nkabom variety at 4 MAP, while Nkabom variety significantly 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 23:1010 and poultry were applied. The greatest root weight was obtained in application of NPK 23:1010, poultry manure, NPK 15:15:15 and combined application of NPK 23:1010 and poultry manure (F6) at 4, 6, 8 and 11 MAP, respectively. At 4 MAP, application of NPK 23:1010 (F3) produced the greatest root weight which significantly (P<0.05) differed from the other treatment means, except combined application of NPK 15:1515 and poultry manure and NPK 15:1515 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 15:1515 only treatment was significantly higher (P<0.05) than all other treatment effects. The combined application of NPK 23:1010 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 3. Effects of variety and application of organic and inorganic fertilizers on mean root tuber girth of cassava at different months after planting in 2014/2015 growing season

Sources	4 MAP	6 MAP	8 MAP	11 MAP
Variety				
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
Fertilizer				
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

3.3 Tuber Girth

Significant (P<0.05) varietal differences were recorded only at 8 MAP with Bankyehemaa producing a greater mean tuber girth than Nkabom variety. On the other sampling days, varietal differences were not significant (Table 3 above). Application of fertilizer significantly (P<0.05) influenced root tuber girth on all days of sampling. The sole application of NPK 15:15:15 produced the greatest mean tuber girth at 4 MAP, which was significantly higher than all other treatment effects, except the combined application of NPK 23:10:10 and poultry manure. At 6 MAP, the treatment effect of poultry manure was greatest, and this was similar to all other treatment effects, except that of the control and combined application of NPK 23:10:10 and poultry manure. At 8 MAP, tuber girth from NPK 15:15:15 only treatment was the greatest, which was significantly higher than all other treatment effects, except that of NPK 23:10:10 (F3) only and poultry manure only treatments. At 11 MAP, treatment effect of the combined application of NPK 23:10:10 and poultry manure was greater than all other treatment effects, except that of NPK 15:15:15 only treatment. On all sampling occasions, the control treatment effect was the lowest.

4. DISCUSSION

4.1 Fresh Tuber Yield, Storage Root Dry Matter and Harvest Index

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. According to [6], an increase in cassava root yield could be due to the increase in the single root weight per stand. In a similar observation, [7] 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 [8] who recorded greater root yield when fertilizer was applied. A study by [9] indicated that fertilizer application can increase root yield of cassava by 30%, while [10] 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 [11] and increase synchrony and reduce losses by converting inorganic N into organic forms [12]. The use of mineral fertilizer in combination with poultry manure has shown to increase yield as much as 60 t/ha of cassava roots [13]. In a similar study [14] 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. A report by [15] showed 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 [16] 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 [17] of 0.64 for Afisiafi and Abasafitaa varieties, but higher than that reported by [8] of 0.43 for Bankyehemaa variety. The indices in the present study were also in the range of 0.54-0.94 obtained by [18]. 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 [19].

4.2 Root Weight

The fertilizer-treated plants produced greater root weight per plant than the control treatment (Table 2). The combined application of poultry manure and NPK 23:10:10 significantly produced greater root 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 [20]. This could have encouraged the production of more and heavier root tubers per plant following good vegetative growth which translated into better production and transfer of photoassimilates.

4.3 Root Girth

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 [21] indicated that greater tuber girth resulted from lesser number of roots for storing the synthesized assimilates supports this assertion. A report by [22] also showed 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. A study by [23] showed 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. [24] observed in their studies that the significant increase in diameter of roots has a positive correlation with fertilizer treatment.

5. CONCLUSION

It was found 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nweke FI, Dixon AGO, Asiedu R, Folayan SA. Collaborative study of cassava in Africa. Cassava variety needs of farmers and potential for growth in Africa. COSCA Working Paper No. 10; 1994.
2. FAOSTAT. Statistical database of the food and agricultural organization of the United Nations; 2011.
   Available:http://faostat.fao.org/
   (Accessed 05 April 2013)

3. MoFA. Agriculture in Ghana: Facts and figures. Produced by statistics, research, and information directorate. Crops Research Institute; 2011.

4. MoFA. Facts and figures, agriculture in Ghana, Ministry of Food and Agriculture, Accra, Ghana; 2009.

5. Safo EY, Ofori F, Dennis EA. Report of the sub-committee on fertilizers use for the national agriculture and forestry. University of Ibadan, Ibadan, Nigeria. 1998;20.

6. Evangeline TC, Thomas L, Ranuiofol A, Telen VB, Ernesto TP. Effectiveness of soil amendment measures in enhancing the growth and yield performance of agroforestry species in degraded uplands. AFIN/R and D Congress- Soil Amelioration, DENR-Ecosystems Research and Development Bureau, College Laos; 2002.

7. Wholey DW, Cock JH. Onset and rate of root bulking in cassava. Experimental Agriculture. 1974;10:193-198.

8. Sarfo H. Growth, yield and root quality of cassava as affected by application of organic and inorganic fertilizers. Master of Philosophy (Agronomy) Thesis, School of Graduate Studies, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi; 2015.

9. Paula MB, de Noguera FD, Tanka RT. Cassava mineral nutrition and fertilization. CIAT Regional Offices in Asia, Department of Agric. Chatackak, Bankok. Thailand. 1983;10900.

10. FAO. Cassava: Food Outlook. 1999;5:10.

11. Santhi R, Selvakumari G. Use of organic Sources of nutrients in crop production. In: Theme papers on integrated nutrient management (Eds.) Kannaiyan et al., Published by Tamil Nadu Agric. Univ. Tamil Nadu Dept. Agriculture. 2000;87–101.

12. Kramer AW, Doane TA, Horwath WR, Kessel CV. Combining fertilizer and organic inputs to synchronize N supply in alternative cropping systems in California. Agriculture, Ecosystem and Environment. 2002;91:233-243.

13. CSIR-Agra projects SHP. Soil Health Projects (SHP-014); 2012.
Available:http://www.csirsoilresearch.org/Agra%20Projects.htm

14. Lou XI, Zhong X, Xia H, Ying PA, Cheng L, Fang SZ and Lin CH. Effects of bio-organic fertilizer on the growth of cassava and the physical, chemical and biological character of soil. Acta Agriculturae Boreali-Occidentalis Sinica. 2008;01:65-71.

15. Adeniji OT, Odo PE, Ibrahim B. Genetic relationships and selection indices for cassava root yield in Adamawa State, Nigeria. African Journal of Agricultural Research. 2011;6(13):2931-2934.

16. Chávez AL, Sánchez T, Jaramillo G, Bedoya JM, Echeverry J, Bolaños EA, Ceballos H, Iglesias CA. Variation of quality traits in cassava roots evaluated in landraces and improved clones. Euphytica. 2005;143:125-133.

17. Baafi E and Safo-Kantanka O. Agronomic evaluation of some local elite and released cassava varieties in the forest and transitional ecozones of Ghana. Asian Journal of Agricultural Research. 2008;2: 32-36.

18. Ojeniyi SO, Samson, AO, Odedina JN, Akinlana F. Effect of different organic nutrient sources and two NPK rates on the performance and nutrient contents of a newly released cassava variety. J. Life Sci. 2012;6:1003-1007.

19. Tavora FJAF, Melo FIO, Pinho, JLN de, Queiro GM de. Yield, crop growth rate and assimilatory characteristics of cassava at the coastal area of Ceaara. Revista Brasileira de Fisiologia Vegetal. 1995;(7) 81-88.

20. Tisdale SL, Nelson WJ, Beaton JD. Soil fertility and fertlizers. Macmillan publishing company. 4th Edition. New York. Tolessa D, Friensen DK (2001). Effect of enriching farmyard manure with mineral fertilizer on grain yield of Maize at Bako, Western Ethiopia. Seventh Eastern and Southern Africa Regional Maize Conference. 11th-15th February. 1993;335-337.

21. Howeler RH, Cadavid LF, Burckhardt E. Response of cassava to V.A. mycorrhizal inoculation and phosphorus application in greenhouse and field experiments. Plant and Soil. 1982;69:327-339.

22. Magoon ML, Krishnan R, Lakshmi KR. Association of plant and tuber characters with yield of cassava trop. Root and Tuber Crops Newsletter. 1972;5:29-30.

23. Ayoola OT, Makinde EA. Complementary organic and inorganic fertilizer application: Influence on growth and yield of Cassava/ maize/melon intercrop with a relayed cowpea. Australian Journal of Basic and Applied Sciences. 2007;1(3):187-192.

24. Leo MV, Kabambe H. Potential to increase cassava yields through cattle manure and fertilizer application: Results from Bunda College, Central Malawi. Lilongwe University of Agriculture and Natural Resources. 2014;45-65.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/17395