Journal of Agricultural Sciences
Vol. 64, No. 4, 2019
Pages 353-366

https://doi.org/10.2298/JAS1904353F
UDC: 635.648(669)
Original scientific paper

GROWTH AND YIELD RESPONSE OF OKRA (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH) TO FERTILIZER TYPES AND TIMES OF APPLICATION IN THE SOUTHERN GUINEA SAVANNA AGRO-ECOZONE OF NIGERIA

Kola Fasakin*, Ade I. Afe and Nurat A. Saka

Department of Crop Production, Kwara State University, Malete, Nigeria

Abstract: A field study was carried out at the Kwara State University Teaching and Research Farm, Malete, to evaluate the response of vegetative growth and immature fruit yield of okra (*Abelmoschus esculentus* (L.) Moench) to three fertilizer types and three times of application. The fertilizer types, used at the rate of 60 kgN/ha, were Kwasu organic-based fertilizer type 2 (KOBF-2), Aleshinloye organo-mineral fertilizer grade A (AOMF-A), and inorganic NPK 15-15-15 fertilizer (NPK), each applied at planting time, 2 weeks after planting (WAP), and 4 WAP. The trial was laid out in a 3 x 3 factorial arrangement in a randomized complete block design and replicated three times. All the data collected were subjected to analysis of variance, using the SAS statistical package, and the treatment means were separated using Duncan's Multiple Range Test at 5% probability level. The result indicated no significant differences in plant height, number of leaves/plant, number of fruits/plant, and the average length of the fruits between fertilizer types and application times. However, there were significant differences in leaf area/plant at 6WAP and fruit yield. Irrespective of the times of application, KOBF-2 gave significantly higher immature fruit yield (2.84 t/ha) than NPK (1.93 t/ha) and AOMF-A (1.72 t/ha). The results thus suggest that the new organic-based fertilizer formulated in this study (KOBF) deserves incorporation into national fertilizer programs for sustainable crop production.

Key words: okra, vegetative growth, fruit yield, inorganic fertilizer, organic-based fertilizer.

Introduction

Okra is a popular fruit vegetable in tropical and sub-tropical countries of the world, including Nigeria where it is cultivated majorly for its immature fruit, which is consumed either in the fresh or dried form (Dupriez and De Leener, 1989; NIHORT, 2000; Schippers, 2000). The tender okra fruit is mostly used to prepare a

*Corresponding author: e-mail: fasakink@yahoo.com

mucilaginous or ‘draw’ soup, which is relished in Nigeria because it greatly eases swallowing of staple starchy morsel foods prepared from yam, cassava roots, and the cereals (NIHORT, 2000). The culinary and nutritive values of the immature okra fruit are due to its rich store of physiologically valuable nutrients, especially water (88.0%), soluble carbohydrates (9.5%, mainly as dietary fiber in the form of mucilage), protein (2.1%), and fair amounts of several minerals (zinc, calcium), vitamins (A, B2, B6, ascorbic acid, folic acid, riboflavin, thiamin), and antioxidants (Fatokun and Chedda, 1983; Grubben and Denton, 2004).

Ordinarily, there are two cultivated okra genotypes in Nigeria: the daylength-sensitive West African okra (*Abelmoschus caillei* (A. Chev.) Stevels) and the common okra (*Abelmoschus esculentus* (L.) Moench). Regardless of the time of planting, during the rainy season, the former does not start to initiate flowering and fruiting until October and, therefore, it is usually cultivated at subsistence level towards the end of the rainy season. The common okra, in turn, is the more commonly cultivated and it has received far more genetic improvement and agronomic studies; the reasons why several improved varieties of it are widely available for cultivation in market gardens and mixed cropping systems (Kochhar, 1986; NIHORT, 2000; Schippers, 2000).

In addition to the use of high-quality seeds of improved varieties for planting the crop, high level of soil fertility and crop protection are other prerequisites for high yield of qualitative okra fruits. NIHORT (2000) has posited that the quantum of okra fruit yield depends to a large extent on the ability of the farmer to replenish plant nutrients removed from the soil by the current and previous crops, maintaining the physical condition of the soil at desirable levels, and preventing undue increases in soil acidity and toxic mineral elements. Maintenance of soil fertility, therefore, is a major consideration in okra production, which in conventional agriculture, is routinely met by the use of inorganic fertilizers.

It is not far-fetched why most farmers prefer inorganic to organic fertilizers. Inorganic fertilizers are readily available, convenient to handle especially during the application, and contain a higher concentration of plant nutrients per unit weight. Notwithstanding these advantages, it is common knowledge that use of inorganic fertilizers, in the long run, poses serious soil environmental pollution and ecosystem balance problems, in addition to systematic impoverishment of the soil and degradation of soil physical properties, all of which lead to crop yield decline (Avery, 1995; Palm and Sanchez, 1991). Also, inorganic fertilizers are becoming increasingly unavailable to resource-poor farmers as a result of ever-rising cost and transportation constraints from urban centers, where they are mainly obtainable, to where they are required in the rural areas.

These setbacks of inorganic fertilizers have given rise to the current advocacy for the adoption of organic and organic-based fertilizers for soil fertility maintenance in crop production systems. These fertilizer types are not only safe for the health of farmers, consumers, and the soil environment but usually leave positive residual effects on the soil for the growth and yield of succeeding crops, which benefits the farmer by way of reduced cost of fertilizing a succeeding crop (Worthington, 2001; Bayu et al., 2006; Makinde and Ayoola, 2008).

Olowoake and Adeoye (2013) have observed that several types of plant residues in Nigeria can be processed, packaged, and made available as organic-based fertilizers. Among such organic fertilizers in Nigeria, some of which have been evaluated on crop growth and yield, only a few are developed in the country exemplified by Aleshinloye organic fertilizer grades A and B (products of Aleshinloye Fertilizer Plant, Ibadan, Oyo State, Nigeria) and Sunshine organic fertilizer grades A and B (developed by Ondo State Government, Akure, Nigeria). While Aleshinloye grade A and Sunshine grade A are composted household wastes amended with mineral fertilizers, Aleshinloye grade B and Sunshine grade B are unamended composts (ODSG, 2012).

Prompted by the need to expand the range of locally-formulated organic-based fertilizers in Nigeria, crop scientists at the Kwara State University Malete (Kwasu) decided to experiment on mixing tithonia plant (*Tithonia diversifolia* L.), poultry manure, and inorganic NPK fertilizer together. The resultant product is called Kwasu organic-based fertilizer (KOBF). The choice of tithonia, a roadside weed having vigorous growth habit, as a component in formulating KOBF was based on its availability virtually everywhere and its potential for raising the levels of the major nutrients in soils (Achieng et al., 2010; Jama et al., 2000). This attempt of the Kwara State University Malete (Kwasu) crop scientists was also informed by the general agreement among several researchers that using a mixture of organic and inorganic fertilizers for soil fertility management significantly performs better on growth and yield of crops than using the single fertilizer types alone (Makinde et al., 2001; Sridhar and Adeoye, 2003; Makinde and Ayoola, 2008; Ogunlade et al., 2011).

Earlier studies on organic and organic-based fertilizers (Akanbi et al., 2000; Olowoake and Adeoye, 2013; Olowoake, 2014) have shown that their potentials are not limited only to sustaining soil fertility, but also extend to greatly improving the physical properties of tropical soils and activating and increasing soil microbial populations that carry out decomposition of soil organic matter, leading to improved crop growth and yields. However, there is no such information on KOBF, because it is a relatively new organic fertilizer. The objective of this study, therefore, is to evaluate the response of okra growth and fruit yield to time of application of KOBF compared to some of the commonly available organic-based and inorganic fertilizer types in Nigeria.

Materials and Methods

Study location

The study was conducted at the Kwara State University Teaching and Research Farm, Malete, Nigeria. Malete is located in the southern Guinea savannah agro-ecological zone of Nigeria, on latitude 08^{O}71'N and longitude 4^{O}44'E of the equator. The local climate is characterized by distinct wet and dry seasons. The wet season commences in March or April and ends in October, with a dry spell from mid-July to mid-August. The dry season starts towards the end of October and lasts until March or April. Meteorological data of the study location during 2017 are presented in Table 1.

Analysis of study location soil and organic-based fertilizers used in the study

Samples of the study location soil were collected at a depth of 0–30 cm, before the commencement of the trial, for laboratory analysis of physico-chemical properties. KOBF-2 and AOMF-A were also analyzed in the laboratory for their nutrient compositions.

Planting material

The okra seeds used for planting were those of Clemson spineless variety; produced, treated, and hermetically packaged by Premier Seed Company Ltd., with germination percent of 99.

Experimental design and layout

Three fertilizer types and three times of application were tested in this study. The fertilizer types were Kwasu organic-based fertilizer type 2 (KOBF-2), Aleshinloye organo-mineral fertilizer grade A (AOMF-A), and inorganic NPK 15-15-15 fertilizer (NPK), each applied at three planting times: 0 WAP, 2 WAP, and 4 WAP. Thus, the trial was laid out in a 3 x 3 factorial structure in a randomized complete block design and replicated three times. Each plot was 3.0m x 3.0m in size with 1.0m alleys between the plots and the replicates, respectively.

Cultural practices

The experimental site was plowed, harrowed, and the plots and replicates pegged out. Three seeds were hill-planted at a spacing of 50cm between and within rows. Seedlings took 4–5 days to begin emerging and were thinned to two healthy and vigorous plants per stand at 2 WAP. Weighed quantities of each of the three fertilizer types, equivalent to 60kgN/ha (Sonkuwar et al., 1997), were applied to designated plots and plant stands by placement and burial about 5 cm from the hole or plant base at 0, 2, and 4 WAP. To forestall activity of leaf-eating and pod-boring insect pests, dichloro-divenyl-phosphate (DDVP) insecticide was applied as a foliar spray at the rate of 50ml/50 liters of water, beginning from 2 WAP and at fortnight interval until harvest commences. Weed control in the plots was performed by regular hoeing and hand pulling.

Data collection and analysis

Using non-destructive methods, the following data, expressed as the mean per plant, were taken from each plot on 4 randomly selected plants from among the 4 plant stands in the innermost rows of each plot: plant height taken with a meter rule from ground level up to the tip of the topmost leaf buds on the main stem; number of expanded leaves per plant; area of the leaves per plant, estimated as the mean of the product of measured length and breadth of each of 4 leaves per plant, then multiplied by a coefficient given by Ross (1967) as 0.69.

Data on immature fruit yield and yield components were collected by harvesting with a sharp knife at a 4-day interval for five consecutive times between 51 and 71 days after planting. The following data were taken: number of fruits per plot, mean individual fruit length, and total fruit yield per plot and treatment, extrapolated to kg/ha. All weight determinations were carried out on a portable top-loading laboratory weighing scale model OHAUS-Traveller. The data collected were subjected to analysis of variance, using the SAS statistical package and the treatment means, where significant, were separated using Duncan's Multiple Range Test at 5% probability level.

Results and Discussion

Climatic elements during the period of the study

Rainfall, temperature and relative humidity observed during the period of the experiment were adequate for okra cultivation. Statistics obtained from the hydrology section of Lower Niger River Basin Development Authority, Ilorin (a few kilometers from the study location) show that in 2017 (Table 1) rain commenced in March and lasted until October with a total of 123.03 cm delivered. Relative humidity during the rainy season ranged between 22.4% and 25.1%, and temperature between 25 and 30^{O}C.

Analysis of soil and organic-based fertilizers

Table 2 shows the physical and chemical properties of the study location soil and the nutrient compositions of the organic-based fertilizers used in this study. The soil was sandy loam and slightly acidic with a pH value of 6.29 in the water. The values of total nitrogen (1.82 mg/kg), available phosphorus (8.48 mg/kg), and potassium (0.88 mg/kg) in the soil were below the critical values for soils of the Guinea savanna (Olowoake and Ojo, 2014). The low content of the major nutrients indicated in the results signifies the low soil organic matter content and the need for nutrient supplementation in order to achieve optimum plant performance (Azeez et al., 2006). Analysis of the organic-based fertilizers indicated that KOBF-2 had substantially more N, P, and K than AOMF-A, in addition to some other micro-nutrients.

Table 1. Meteorological data of the study location during 2017.

Months	Rainfall (cm)	Temperature (°C)	Relative humidity (%)
January	2.20	27.06	20.96
February	0.00	28.54	21.78
March	33.50	30.60	25.01
April	12.73	29.15	25.08
May	8.44	27.62	24.65
June	12.32	27.03	23.83
July	4.30	29.09	23.57
August	18.74	25.01	22.65
September	20.27	25.66	22.41
October	12.73	26.85	23.24
November	0.00	28.05	23.14
December	14.00	27.79	21.75

Source: Lower Niger River Basin Development Authority, Ilorin (Hydrology Section, 2017).

Vegetative growth of okra as affected by fertilizer type and application time

The responses of the vegetative growth characters of okra to the three fertilizer types and times of application are presented in Tables 3 and 4. Each of the vegetative growth characters measured (plant height, number of leaves and leaf area per plant) increased numerically in magnitude as growth progressed, but the response was not significant between the fertilizer types except for leaf area per plant at 6WAP, which was higher for KOBF-2 than NPK and AOMF-A. Considering the application time of each of the fertilizer types, the vegetative characters of okra were not significantly influenced ($p \leq 0.05$) by the three times of application. However, in numerical terms, 2 WAP gave higher values than when the fertilizer was applied at planting (0 WAP) and 4 WAP for leaf area per plant using KOBF-2 and NPK but not AOMF-A.

Table 2. Compositions of the study location soil and organic-based fertilizers.

	Study location soil	Kobf-2	Aomf-a
Physical properties			
Sand (%)	58.69		
Silt (%)	19.31		
Textural class	Sandy loam		
Chemical properties			
pH (H_2O)	6.29	6.48	
Organic carbon (g kg^{-1})	1.54	3.59	
Available P (mg kg^{-1})	8.48	5.55	0.8
Total N (mg kg^{-1})	1.82	4.41	1.2
Exchangeable bases			
K (mg kg^{-1})	0.88	3.21	2.9
Na (mg kg^{-1})	1.98	1.28	
Mg (mg kg^{-1})	1.82	1.21	
Mn (mg kg^{-1})	1.02		
Zn (mg kg^{-1})	2.87		
Cu (mg kg^{-1})	0.87		
Ca (mg kg^{-1})	2.46	8.48	
Fe (mg kg^{-1})	3.01		

KOBF-2 = Kwasu organic-based fertilizer type 2; AOMF-A = Aleshinloye organo-mineral fertilizer grade A.

Table 3. Effects of the application time of different fertilizers on vegetative growth characters of okra.

Treatments		Plant height (cm)			No. of leaves/plant			Leaf area/plant (cm^2)		
Fertilizer type	Application time	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP
KOBF-2	0 WAP	6.53a	11.03a	25.03a	3.17a	4.93a	7.00a	5.63a	56.10a	230.53ab
	2 WAP	5.50a	9.07a	23.40a	3.00a	4.90a	7.27a	2.17a	54.43a	269.83a
	4 WAP	6.37a	10.20a	22.67a	3.10a	5.70a	7.27a	3.77a	47.77a	195.23ab
AOMF-A	0 WAP	5.43a	12.90a	13.43b	2.77a	5.37a	5.93a	1.77a	32.37a	128.57b
	2 WAP	5.83a	9.33a	18.87ab	3.00a	5.07a	5.83a	2.86a	30.30a	140.07b
	4 WAP	6.17a	9.77a	20.47ab	3.17a	5.43a	5.77a	3.63a	42.93a	169.77ab
NPK	0 WAP	5.93a	9.43a	19.93ab	3.00a	5.37a	6.10a	3.10a	39.93a	137.97b
	2 WAP	5.70a	11.07a	23.10a	3.10a	5.20a	6.37a	4.47a	46.13a	187.97ab
	4 WAP	6.40a	10.10a	20.93ab	3.10a	5.07a	6.53a	5.86a	37.33a	162.90ab

Means in the same column followed by at least one common letter are not significantly different. KOBF-2 = Kwasu organic-based fertilizer type 2; AOMF-A = Aleshinloye organo-mineral fertilizer grade A; NPK = Inorganic NPK 15-15-15 fertilizer; WAP = Weeks after planting.

Irrespective of the time of application (Table 4), KOBF-2 gave significantly higher values at 6 WAP than AOMF-A and NPK for all the vegetative characters measured, except the number of leaves per plant where values recorded for KOBF-2 were similar with NPK. At this time also, irrespective of fertilizer type, application at planting time (0 WAP) gave numerically but not significantly lower values than application at 2 and 4 WAP for plant height and leaf area per plant in AOMF-A and NPK.

Table 4. Effects of fertilizer type and time of application on vegetative growth characters of okra.

Treatments	Plant height (cm)			No. of leaves/plant			Leaf area/plant (cm^2)		
Fertilizer type	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP	2WAP	4WAP	6WAP
KOBF-2	6.13	10.10	23.70a	3.09	5.12	7.12a	3.87	52.77a	231.87a
AOMF-A	6.01	10.20	17.59c	2.98	5.29	5.84b	2.77	35.20c	146.13b
NPK	5.81	10.67	21.32bc	3.01	5.21	6.33ab	4.48	41.13ab	162.94b
Application time									
0WAP	5.97	11.12	19.47	2.98	5.22	6.34	3.50	42.80	165.69
2WAP	5.68	9.82	21.79	3.03	5.06	6.49	3.16	43.62	199.29
4WAP	6.31	10.02	21.37	3.12	5.40	6.52	4.42	42.68	175.97
S.E.	NS	NS	1.52	NS	NS	0.31	NS	5.23	19.15

Means in the same column followed by at least one common letter are not significantly different. KOBF-2 = Kwasu organic-based fertilizer type 2; AOMF-A = Aleshinloye organo-mineral fertilizer grade A; NPK = Inorganic NPK 15-15-15 fertilizer; WAP = Weeks after planting; S.E. = Standard error.

Fruit yield and yield components of okra as affected by fertilizer types and application time

The effects of application time of the fertilizer types tested on immature fruit yield and yield components of okra are presented in Tables 5 and 6. There were no significant ($p \leq 0.05$) differences in the number of fruits per plot and the average length of the fruits among the fertilizer types and times of application. Although more fruits with longer length were recorded with the application of KOBF-2, compared to AOMF-A and NPK (Table 5), the values were not significantly different. However, fruit yield was significantly influenced by fertilizer type at various times of application. For instance, there was no significant difference between the three application times of KOBF-2 but AOMF-A at planting was superior to 2 and 4 WAP whereas, for NPK, application at 2 WAP was found to be superior at planting. Overall, the highest fruit yield (3.42 t/ha) was obtained with KOBF-2 applied at 2WAP and the least (1.38 t/ha) with NPK at 0 WAP.

Among the fertilizer types tested, irrespective of the time of application (Table 6), KOBF-2 gave significantly higher fruit yield (2.84 t/ha) than NPK and AOMF-

A, both having 1.93 and 1.72 t/ha, respectively. With respect to the time of fertilizer application, 2 WAP was found to be superior to 0 and 4 WAP.

Table 5. Effects of application time of different fertilizers on immature fruit yield and yield components of okra.

Fertilizer type	Application time	No. of fruits	Fruit length (cm)	Immature fruit yield (t/ha)
KOBF-2	0WAP	15.67a	9.03a	2.20ab
	2WAP	14.67a	7.30a	3.42a
	4WAP	16.67a	8.83a	2.90ab
AOMF-A	0WAP	10.00a	7.03a	2.17b
	2WAP	10.66a	7.23a	1.54c
	4WAP	10.67a	7.57a	1.46c
NPK	0WAP	12.00a	7.76a	1.38c
	2WAP	15.33a	7.80a	2.57b
	4WAP	13.33a	7.10a	1.83bc

Means in the same column followed by at least one common letter are not significantly different. KOBF-2 = Kwasu organic-based fertilizer type 2; AOMF-A = Aleshinloye organo-mineral fertilizer grade A; NPK = Inorganic NPK 15-15-15 fertilizer; WAP = Weeks after planting.

Table 6. Effects of fertilizer type and time of application on immature fruit yield and yield components of okra.

Treatments	No. of fruits	Fruit length (cm)	Immature fruit yield (t/ha)
Fertilizer type			
KOBF-2	15.67	8.39	2.84a
AOMF-A	10.44	7.56	1.72c
NPK	13.55	7.28	1.93bc
Application time			
0 WAP	12.57	7.94	1.92bc
2 WAP	13.56	7.92	2.51a
4 WAP	13.56	9.83	2.06bc

Means in the same column followed by at least one common letter are not significantly different. KOBF-2 = Kwasu organic-based fertilizer type 2; AOMF-A = Aleshinloye organo-mineral fertilizer grade A; NPK = Inorganic NPK 15-15-15 fertilizer; WAP = Weeks after planting; S. E. = Standard error.

A general overview of the results in this study shows that plant height and number of leaves as well as the area of the leaves per plant, except leaf area per plant at 6WAP, of the okra variety used in this study (Clemson spineless) were not significantly different between the fertilizers tested. The fruit yield components measured (number of fruits per unit area of land and mean individual fruit length) also showed a similar response as the above-mentioned vegetative growth characters. The non-significant difference in the number of leaves is probably because the character is orthogenic in nature and, therefore, not readily subject to environmental influence.

The superiority of KOBF-2 applied at 2WAP over NPK and AOMF-A also applied at 2 WAP on leaf area per plant at 6WAP may be attributable to the relative differences in ease of mineralization of the component materials in these fertilizer types. KOBF-2, being a mixture of the tithonia plant and poultry manure amended with little inorganic fertilizer, proved to release its nutrients more readily, raising the levels of the major nutrients in the soil. This has agreed with Makinde et al. (2001) and Akanbi et al. (2000) that mixing organic and inorganic fertilizers is a sound soil fertility management strategy, better than the use of the organic and inorganic fertilizers individually. NPK is entirely an inorganic fertilizer, characterized by a rapid release of its constituent nutrients in the soil. AOMF-A, in turn, being from majorly household refuse, tends to mineralize more slowly compared to the other fertilizer types tested. In other similar studies, Sridhar and Adeoye (2003) and Ogunlade et al. (2011) have reported that the application of combined plant materials, poultry manure, and inorganic fertilizers significantly improves growth and fruit yield of okra better than the application of each fertilizer material separately.

Although the vegetative characters of okra were not significantly influenced by the three fertilizer application times tested, in numerical terms, values for leaf area per plant at 2 WAP (199.29 m^2) were higher than at planting time (165.69 m^2) and at 4 WAP (175.97 m^2). This may be attributed to the fact that when applied at planting time, the levels of available nutrients from each of the fertilizers must have declined drastically as growth progressed such that they were no more sufficient when needed most to sustain growth and yield. The higher overall values observed between the fertilizers when applied at 2 WAP suggest that mineralized nutrients were still available in sufficient amounts in the soil to support optimum okra plant growth and yield of fruits. However, at 4 WAP application time, probably the fertilizers have not yet mineralized sufficiently to make enough nutrients available at the time of flowering and fruiting. Abdulmaliq et al. (2015) have observed a similar result.

Application of AOMF-A at planting time gave significantly higher fruit yield values (2.17 t/ha) than at 2 and 4 WAP (1.54 and 1.46 t/ha, respectively), suggesting that this organo-mineral fertilizer requires a relatively long period of time after application to mineralize and make its constituent nutrients fully available for plant use. Namely, application times of 2 and 4 WAP appear not long enough for its complete mineralization and nutrient release for the use of the crop. AOMF-A is derived from majorly urban household refuse (ODSG, 2012), which, as shown in this study, tends to mineralize more slowly compared to the other fertilizer types tested.

For KOBF-2, irrespective of the time of application, immature fruit yields among the three fertilizer application times were not significantly different, although, in numerical terms, application at planting time gave lower fruit yield (2.20 t/ha) than at 2 and 4 WAP (3.42 and 2.90 t/ha, respectively), suggesting that this organic-based fertilizer readily mineralized and made its constituent nutrients available in the soil, with 2 WAP appearing to be more promising.

The effects of application times of NPK, in turn, closely followed those of KOBF-2. Application of NPK fertilizer to the okra crop at 2 WAP gave significantly higher fruit yield (2.57 t/ha) than at planting time (1.38 t/ha), although numerically lower it was not significantly different from when the fertilizer was applied at 4 WAP (1.83 t/ha). NPK as inorganic fertilizer is characterized by rapid mineralization and release of its constituent nutrients in the soil for plant uptake. Moyin-Jesu (2007) has observed that, compared to organic fertilizers, inorganic fertilizers quickly release their nutrients to the soil.

Therefore, the lower okra fruit yields obtained in this trial when NPK was applied at planting time, compared to at 2 WAP, suggest that available nutrients in the soil have depleted as a result of the long period of time (7 weeks) between the placement of the fertilizer and the commencement of fruiting. Similarly, the lower fruit yields when NPK was applied at 4 WAP, compared to at 2 WAP, suggest suboptimal levels of nutrients in the soil due to the short period of time (2 weeks) before fruiting commenced at 7 weeks, meaning that not enough of the fertilizer has been mineralized and the nutrients made available to the okra plants. These results are in agreement with the findings of Idowu and Kadiri (2013) and Iyagba et al. (2013) that the fresh fruit yield parameters of an okra crop (number of fruits/plant, fruit length, fruit weight/plant, and fruit weight/ha) are linked to the availability of adequate amounts of nutrients in the soil, especially N, P, and K, as at the time of flowering and fruiting.

Conclusion

Overall, the performances of the 3 fertilizer types tested can be ranked in the order KOBF-2 > NPK15-15-15 > AOMF-A. However, with respect to the time of application, KOBF-2 applied at 2 WAP was found to perform better than NPK, which in turn was superior to AOMF-A. The new organic-based fertilizer formulated in this study (KOBF) is thus recommended for incorporation into national fertilizer programs for sustainable crop production.

Acknowledgements

The authors are profoundly grateful to the Kwara State University’s Center for Sponsored Projects, for approving an ETF Research Grant with which this work was carried out.

References

Abdulmaliq, S.Y., Isah, M.K., Bello, O.B., & Ahamood, J. (2015). Effects of time of application and rates of poultry manure on the performance of okra (*Abelmoschus esculentus* L.) in southern guinea savanna ecology of Nigeria. *Journal of Organic Agriculture and Environment, 3,* 84-94.

Achieng, J.O., Ouma, G., Odhiambo, G., & Muyekho, F. (2010). Effect of *Tithonia diversifolia* (Hemsley) and inorganic fertilizers on maize yield on Alfisols and Ultisols of western Kenya. *Agriculture and Biology Journal of North America, 1(5),* 740-747.

Akanbi, W.B., Adediran, J.A., Togun, A.O., & Soul, R.A. (2000). Effect of organic-base fertilizer on the growth, yield and storage life of Tomato (*Lycopersicon esculentum*). *Bioscience Research Communication, 12 (24)*, 14-18.

Avery, D.T. (1995). *Saving the planets with pesticide plastic: The environmental triumph of high-yielding farming.* Hudson Institute, Indianapolis, USA.

Azeez, J.O., Adetunji, M.T., & Lagoke, S.T.O. (2006). Response of low-nitrogen tolerant maize genotypes to nitrogen application in a tropical Alfisol in northern Nigeria. *Soil Tillage Research, 91*, 181-185.

Dupriez, H., & De Leener, P. (1989). *African gardens and orchards: Growing vegetables and fruits.* Macmillan Pub. Ltd. in association with Terres et Vie and CTA.

Fatokun, C.A., & Chedda, H.R. (1983). The effects of nitrogen and phosphorus on yield and chemical composition of Okra (*Abelmoschus esculentus*). *Acta Horticulturae 123,* 283-290.

Idowu, O.O., & Kadiri, M. (2013). Growth and yield response of okra (*Abelmoschus esculentus* Moench) to spent mushroom compost from the cultivation of *Pleurotus ostreatus* an edible mushroom. *Academia Journal of Agricultural Research, 1 (3)*, 39-44.

Iyagba, A.G., Onuegbu, B.A., & Ibe, A.E. (2013). Growth and yield response of okra (*Abelmoschus esculentus* (L.) Moench) to NPK fertilizer rates and weed interference in Southeastern Nigeria. *International Research Journal of Agricultural Science and Soil Science, 3(9),* 328-335.

Katung, M.D., Olanrewaju, J.D., Gupta, U.S., & Kureh, I. (1996). Fruit and seed yields of Okra as influenced by farmyard manure and nitrogen fertilizer. In: *Proceedings of 14th HORTSON Conference, Ago-Iwoye, Nigeria*. p. 201.

Kochhar, S.L. (1986). *Tropical Crops: A Textbook of Economic Botany*. 1st Edition. MacMillan Publishers, London, UK.

Moyin-Jesu, E.I. (2007). Use of plant residues for improving soil fertility, pod nutrients, root growth and pod weight of okra (*Abelmoschus esculentus* L.). *Bioresource Technology, 98 (11),* 2057 - 2064.

NIHORT (2000). National Horticultural Research Institute, Ibadan: 25 years of research into horticultural crops development in Nigeria (1975-2000). O.A. Denton, K.O. Alasiri, and M.A. Adejoro (Eds.). *Published by Horticultural Society of Nigeria.*

ODSG (2012). *Waste to wealth*. Ondo State Waste Management Bulletin on the Use of Organic and Organomineral Fertilizers. Ondo State Government, Nigeria.

Ogunlade, M.O., Adeyemi, E.A., Ogunleti, D.O., & Ibiyomi, P.S. (2011). Effect of cocoa pod husk, urea fortified cocoa pod husk and NPK fertilizers on the growth and yield of *Solanum macrocarpon. International Journal of Organic Agricultural Research and Development, 3*, 1-3.

Olowoake, A.A. (2014). Influence of organic, mineral and organomineral fertilizers on growth, yield and soil properties in grain amaranth (*Amaranthus cruentus* L.). *Journal of Organics (JO), 1* (1), 39-47.

Olowoake, A.A., & Adeoye, G.O. (2013). Influence of differently composed organic residues on the yield of maize and its residual effects on the fertility of an Alfisol in Ibadan, Nigeria. *International Journal of Agriculture, Environment and Biotechnology, 6* (1), 79-84.

Olowoake, A.A., & Ojo, J.A. (2014). Effect of fertilizer types on the growth and yield of *Amaranthus caudatus* in Ilorin, Southern Guinea Savanna Zone of Nigeria. *Advances in Agriculture Volume 2014. Hindawi Publishing Corporation*.

Palm, C.A., & Sanchez, P.A. (1991). Nitrogen release from the leaves of some tropical legumes as affected by their lignin and poly-phenolic contents. *Soil Biology and Biochemistry, 23* (1), 83-88.

Ross, V.K. (1967). Voprosu opredeleniya listovof poverkhnosti rastenit. (On determination of leaf area). In: Fitoaktinometricheskie Issledovaniya Rastitel'nogo Pokrova, Valgus, Tallin. pp. 150-162.

Schippers, R.R. (2000). *African indigenous vegetables: An overview of the cultivated species.* The Univ. of Greenwich and the ACP-EU Tech. Center for Agric. and Rural Coop., London.

Sonkuwar, R.H., Mahakal, K.H., & Lale, B.B. (1997). Effect of different levels of nitrogen on growth and yield in okra varieties. *PKV Research Journal, 21* (2), 202-204.

Sridhar, M.K.C., & Adeoye, G.O. (2003). Organomineral fertilizers from urban wastes. *The Nigerian Field, 68*, 91-111.

Worthington, V. (2001). Nutritional quality of organic versus conventional fruits, vegetables and grains. *Journal of Alternative and Complimentary Medicine, 7* (2), 161-173.

Received: June 21, 2018
Accepted: October 10, 2019

RAST I PRINOS BAMIJE (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH) U ZAVISNOSTI OD TIPA ĐUBRIVA I VREMENA PRIMENE U AGRO-EKO ZONI JUŽNOGVINEJSKE SAVANE U NIGERIJI

Kola Fasakin*, Ade I. Afe i Nurat A. Saka

Odsek za proizvodnju useva, Državni univerzitet u Kvari, Malete, Nigerija

R e z i m e

Sproveden je poljski ogled na Nastavno-istraživačkom dobru Državnog univerziteta u Kvari, Malete, kako bi se procenio odgovor vegetativnog rasta i prinosa nezrelog ploda bamije (*Abelmoschus esculentus* (L.) Moench) na tri tipa đubriva i tri vremena primene. Tipovi đubriva, u količini od 60 kgN/ha, bili su Kwasu organsko đubrivo tipa 2 (KOBF-2), Aleshinloye organsko-mineralno đubrivo stepena A (AOMF-A), i neorgansko NPK 15-15-15 đubrivo (NPK). Sva navedena đubriva su primenjena u vreme setve, 2 nedelje posle setve (engl. *weeks after planting* – WAP), i 4 nedelje posle setve. Ogled je postavljen u 3 x 3 faktorijalnom rasporedu u potpunom slučajnom blok dizajnu u tri ponavljanja. Svi podaci koji su prikupljeni obrađeni su analizom varijanse, korišćenjem SAS statističkog paketa, a srednje vrednosti tretmana odvojene su korišćenjem Dankanovog testa višestrukog raspona na nivou od 5% verovatnoće. Rezultat je pokazao da nema značajnih razlika u pogledu visine biljke, broja listova po biljci, broja plodova po biljci, i prosečne dužine plodova između tipova đubriva i vremena primene. Međutim, postojale su značajne razlike kod površine lista po biljci 6 nedelja posle setve i prinosa ploda. Bez obzira na vreme primene, upotrebom KOBF-2 postignut je značajno viši prinos nezrelog ploda (2,84 t/ha) nego upotrebom NPK (1,93 t/ha) i AOMF-A (1,72 t/ha). Rezultati dakle sugerišu da novo organsko đubrivo formulisano u ovom istraživanju (KOBF) zaslužuje da bude uključeno u nacionalne programe o đubrivima za održivu proizvodnju useva.

Ključne reči: bamija, vegetativni rast, prinos ploda, neorgansko đubrivo, organsko đubrivo.

Primljeno: 21. juna 2018.
Odobreno: 10. oktobra 2019.

*Autor za kontakt: e-mail: fasakink@yahoo.com