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Influence of Sole and Combined Application of NPK (15:15:15) Fertilizer and Poultry Manure on Growth and Yield of Okra (*Abelmoschus esculentus* L.) Varieties in Aliero, Kebbi State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author AM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author HYS managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Field trials were conducted at the University Orchard Aliero, Kebbi state University of Science and Technology Aliero, during the 2017 and 2018 dry seasons, to study the growth and yield of Okra (*Abelmoschus esculentus* L. Moench) varieties influenced by sole and combined application of NPK (15:15:15) and Poultry manure. The treatments consisted of a factorial combination of three Okra varieties: LD88, NHAE47-4 and Dogo; and three level of nutrients: 800 kg NPK (15:15:15) ha^{-1}, 100%PM ha^{-1} equivalent to 6.6 t ha^{-1} and 50% NPK+50% PM ha^{-1} (400 kg of NPK [15:15:15] + 3.3 t of PM ha^{-1}) and the untreated control, each designed to supply the recommended dose of 120 kg N ha^{-1} using a compound fertilizer NPK (15:15:15) and poultry manure and cow dung. Results revealed that plant height, number of leaves, number of pods per plant, mean pod weight (g), mean

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pod length (cm), fruit yield per hectare were significantly increased when the recommended N dose of 120 kg N ha^{-1} was applied using only NPK (800 kg NPK [15:15:15 ha^{-1}]) or a combination of NPK+PM at 50:50 ratio in conjunction with variety NHAE47-4. Based on the results of this study, it could be concluded that the integration of organic and inorganic fertilizers in form of NPK fertilizer and poultry manure at 50:50 ratio in conjunction with variety NHAE47-4, could be adopted for higher pod yield.

Keywords: Okra; Abelmoschus esculentus L. Moench; NPK; poultry manure; okra pod yield; Nigeria.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is an important vegetable crop consumed worldwide. It is a member of the *Malvaceae* family, widely cultivated in the tropics and subtropics for its immature edible green fruits which are consumed as a vegetable [1]. In Nigeria, okra is usually grown in home gardens and fields both during the wet and dry seasons, with the dry season production being carried out under irrigation [2]. It has a great demand because it forms an essential part of the human diet. It is grown mainly for its young tender fruits and can be found in most markets in Africa [3]. It is produced and consumed all over the country for the mucilaginous or "draw" property of the fruit that aid easy consumption of the staple food products. Nutritionally, tender green fruits of okra are important sources of vitamins and minerals such as vitamins A, B_1, B_3, B_6, C and K, folic acid, potassium, magnesium, calcium and trace elements such as copper, manganese, iron, zinc, nickel, and iodine [4], which are often lacking in the diet of people in most developing countries. On the average, young green fruit contains 86.1% moisture, 9.7% carbohydrate, 2.2% protein, 0.2% fat, 1.0% fibre and 0.8% ash [5]. Its importance ranked above most other vegetables including cabbage, amaranths, and lettuce [6].

Vegetable crop producers in the tropics are bedeviled with the problem of maintaining soil fertility. This is because the native fertility of most agricultural soils in this region is low and cannot support suitable crop production over a long period without the use of fertilizers. This problem is compounded by the scarcity and high cost of inorganic fertilizers which has forced farmers to make use of fertilizers rates that are lower than the optimum with its resultant reduction in yield. The scarcity of inorganic fertilizer associated with high cost, has created a lot of problems in arable crop production in Nigeria. In the past, farmyard manure has been used to improve and supplement soil nutrients [7], but with the advent of inorganic fertilizer, there was a reduction in the use of organic manure by farmers as source of plant nutrients and soil improvement, because of relative ease of application and quick results with inorganic fertilizer application. On the other hand, organic manures generally improve the soil physical, chemical and biological properties along with conserving the moisture holding capacity of soil and thus resulting in enhanced crop productivity along with maintaining the quality of crop produce [8].

Although the organic manures contain plant nutrients in small quantities as compared to the inorganic fertilizers, the presence of growth promoting principles like enzymes and hormones, besides plant nutrients makes them fertility soil enhancers and productivity [9]. Despite the beneficial qualities of poultry manure, a high rate may be required to ensure adequate soil coverage especially in fields with low fertility and those that have been subjected to inorganic fertilization for many years [10]. A lot of work has been done with okra and other related vegetables but not much has been reported on the influence of NPK (15:15:15) and poultry manure on the development of Okra varieties. Therefore, the objective of this study was to assess the performance of okra varieties under the sole and combined application of NPK (15:15:15) and poultry manure in Aliero, on the Kebbi state of Nigeria.

2. MATERIALS AND METHODS

2.1 Experimental Site

The research was carried out in two dry seasons of 2017 and 2018 at Kebbi state University of Science and Technology Aliero, Orchard (lat. 12°18.64'N; long. 4°29.85'E; 262 above sea level). Aliero is located at in Sudan Savanna ecological zone of Nigeria. The area has a long dry season that is characterized by cool dry air (harmattan) that prevails from November to February; and hot dry air extending from March to May. The locations were used for cultivation of vegetable and cereal crops.

2.2 Land Preparation and Field Layout

The site was ploughed and harrowed to obtain good tilth. The soil was levelled and constructed into seed beds; water channels were constructed to facilitate free and efficient water movement and uniform distribution on the plots. The plot size was 2.5 x 3 m (7.5 m^2). Space measuring 1.5 m was left between blocks and 0.5m between plots. The net plot area consisted of the two middle rows (2.5 x 1.0 m = 2.5 m^2). Organic manures (Poultry manure and Cow dung) was then applied evenly into the seedbed according to treatment in order to improve its fertility status and then watered. The seed bed left for 5 days with daily watering to stimulate the release the nutrients from manure applied.

2.3 Plant Materials

Two varieties of okra (LD88, and NHAE47-4) were sourced from the National Horticultural Research Institute (NIHORT) Bagauda sub-station, Kano. While a variety of *Dogo* was out sourced locally from Jega.

2.4 Soil and Organic Manure Analysis

Soil samples were randomly collected from the depth of 0-30 cm across the experimental sites. The samples were bulked to form a composite sample and sub-samples about 200 g were collected using coning and quartering method. The samples were air dried, grounded, sieved and analyzed for physical and chemical properties (Table 1). Poultry manure sample was collected and analyzed for chemical characteristics (Table 2).

2.5 Treatment and Experimental Design

The treatments consist of three (3) okra varieties (LD 88, NHAE47-4 and Dogo variety) and three (3) levels of Organic and Inorganic fertilizers, each designed to supply 120 kg N ha^{-1} using NPK (15:15:15) and poultry manure. The treatments were: 800 kg NPK (15:15:15) ha^{-1}; 100% PM ha^{-1} equivalent to 6.6 t ha^{-1}; 50% NPK+50% PM ha^{-1} (400 kg of NPK [15:15:15] + 3.3t of PM ha^{-1}) and the untreated control. The experiments were laid out in a Factorial Randomized Complete Block Design (FRCBD) with three (3) replications.

2.6 Seed Treatment and Sowing

Prior to sowing, the seeds were treated with Apron star at the rate of 10 g of the chemical per 4.0 kg of seed, to protect the seeds from soil-borne diseases and pests. Seeds were dibbled at an intra and inter row spacing of 50 x 50 cm.

2.7 Pesticide Application

Okra plants were protected against insect pests and diseases by regular spraying of an appropriate mixture of *Cypermerthrin* plus dimethoate at the rate of 4ml L^{-1} of water at 10 days interval prior to flowering and 5 days interval continuously after flowering till maturity.

Table 1. Physical and chemical properties of soil of the experimental site during 2017/2018 dry session

	2017	2018
Physical and chemical properties	**0–30 cm depth**	
Particles size analysis		
P^H	6.60	6.11
Organic Carbon %	1.04	0.87
Organic Matter %	1.79	2.01
Total N %	0.084	0.093
P mg/kg	0.93	1.05
Ca Cmol/kg	0.50	0.78
Na Cmol/kg	0.52	0.62
Mg Cmol/kg	0.80	0.74
K Cmol/kg	1.95	2.56
CEC Cmol/kg	8.40	8.94
Sand %	63.3	61.7
Silt %	24.9	28.2
Clay %	11.8	10.1

Table 2. Chemical composition of poultry manure (PM) during 2017/018 dry season

Character	Poultry manure	
	2017	**2018**
Organic carbon (gkg^{-1})	3.11	3.26
pH	6.20	5.94
Total N (mg kg^{-1})	1.76	1.83
Na (mg kg^{-1})	140	138
K (mg kg^{-1})	2500	2500
Ca (mg kg^{-1})	0.44	0.55
P (mg kg^{-1})	7.83	8.04

2.8 Irrigation

Water pump machine was used to draw water from the source (tube-well) to the experimental field through the constructed water channels. Irrigation was scheduled at 3 - 4 days interval depending on the crop's need.

2.9 Weeding

Weeds were controlled manually using hand hoe at 3 and 6 WAP and occasional hand pulling when necessary to ensure weed-free plots.

2.10 Harvesting

Harvesting was done by picking fresh tender pods. Pods were snapped off or cut with sharp knife.

2.11 Data Collection

Data were collected on the following yield parameters:

2.11.1 Plant height (cm)

Plant height of 5 tagged plants was recorded at 6 and 8WAP. This was achieved by measuring the plant from ground level to the tallest growing point using a measuring tape. The mean was thereafter determined and recorded.

2.11.2 Number of leaves

Number of leaves of 5 tagged plants was counted and the mean number per stand was recorded for each plot at 6 and 8 WAP

2.11.3 Pods plant^{-1}

The number of green pods per plant was counted at every picking day from 5 randomly selected and tagged plants in each plot. The total number of pods obtained from the selected plants was divided to get the average number of pods per plant.

2.11.4 Mean pod weight (g)

Average fresh pod weights from 5 randomly taken pods from each net plot area were measured using a digital balance and the mean was recorded.

2.11.5 Pod mean length (cm)

The lengths of 5 fresh pods collected from sample plants were measured and the mean was recorded.

2.11.6 Pod yield (t ha^{-1})

Fresh pods weight per plot was extrapolated to tons per hectare.

2.12 Data Analysis

The data collected were subjected to analysis of variance (ANOVA). The treatment means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Varietal Response

Results revealed a significant effect ($P \leq 0.05$) in relation to height and variety, 6 and 8 weeks after planting, in both years (Table 3). Dogo variety exhibited the highest plant height (36.16cm and 43.90 cm) in 2017 season at 6 and 8WAP respectively which was followed by LD88. A similar trend was also observed in 2018 season. The higher values obtained from Dogo variety could be due to genetic factor as Dogo is a characteristically tall okra variety. These results correspond with the findings of Ojo et al., [11] that Dogo variety produced taller plants than the improved variety. NHAE47-4 had the lowest plant height at both 6 and 8WAP [11].

A significant effect ($P \leq 0.05$) of variety was observed as regards to the number of leaves produced at 6 and 8 WAP (Table 3). At 6 WAP, Dogo variety and LD88 produced the highest number of leaves (18.62 and 18.25) while NHAE47-4 had the lowest numbers of leaves (12.72) in 2017 season. At 8WAP, LD88 also recorded the highest number of leaves (25.60) followed by Dogo variety (23.61) whereas NHAE47-4 recorded the lowest number of leaves (15.40). A similar trend was maintained during 2018 season. The higher number of leaves produced by LD88 and Dogo variety could be attributed to their genetic make-up. This is in line with the assertion by Ayoub and Afra [12] who reported that differential growth of crops under similar environmental conditions is normally the result of differences in the genetic make-up of the crops.

A significant effect ($P \leq 0.05$) of variety as regards to number of fruits per plant was observed (Table 5). Dogo variety produced the highest number of pods (13.12) which was followed by LD88 (11.98) and NHAE47-4 (11.73) in 2017 season. In 2018 season, NHAE47-4 (13.82) and Dogo variety produced a significantly higher number of pods per plant whereas LD88 produced the lowest number of fruits. The higher number of pods obtained from NHAE47-4 could be because it is an improved variety and improved varieties are more efficient converters of photosynthetic materials into yield. Ojo et al., [11] reported a similar trend on the okra varieties they worked with. Also, the higher number of pods obtained from Dogo variety; disagreeing with Ojo et al., [11], that report that's said improved varieties are more efficient converters of photosynthetic materials into yield.

A significant effect ($P<0.05$) of variety was observed as regards to mean fruit weight (Table 5). NHAE47-4 had the highest fruit weight (19.48 g) and (20.44 g) followed by Dogo variety [(16.47 g) and (17.55 g)] and LD88 [(14.32 g) and (17.97 g)] for 2017 and 2018 dry seasons respectively. The higher pod weight recorded by NHAE47-4 could be because it is an improved variety therefore, more efficient in the utilization of photosynthetic materials. This result is in accordance with the findings of Ojo et al. [11], who observed that Dogo variety produces lighter fruit compared to NH 47-4(an improved variety).

Significant effect ($P\leq0.05$) as regards to mean pod length was observed among the varieties in both years (Table 5). Dogo variety and LD88 recorded significantly the highest fruit length [(6.32 cm) and (7.21 cm)] and [(5.97 cm) and (7.18 cm)]. NHAE47-4 had the lowest fruit length [(5.40 cm) and (5.76 cm)] in 2017 and 2018. The longer fruit length obtained from the LD88 could be as a result of its improved nature. These results are in agreement with the findings of Jamala et al., [13] in their work with local and improved varieties of okra, they reported that local variety had the shortest fruit length. Also, the longer fruit length obtained from the Dogo variety could be due to genetic factor as Dogo is a characteristically tall okra variety and this disagreed with the findings of Jamala et al., [13].

A significant effect ($P\leq0.05$) of variety as regards to fruit yield of okra was observed (Table 5). NHAE47-4 promoted the highest fruit yield [(5.62t ha^{-1}) and (6.80t ha^{-1})] in 2017 and 2018 followed

Table 3. Plant height and number of leaves of okra varieties as influenced by NPK (15:15:15) and poultry manure during 2017/2018 dry season

Treatment	Plant height (cm)				Number of leaves			
	2017		2018		2017		2018	
	6WAP	8WAP	6WAP	8WAP	6WAP	8WAP	6WAP	8WAP
Fertilizer								
Control	23.90c	27.39b	28.39b	32.64c	12.72c	15.98b	13.90b	16.76c
800kgNPK (15:15:15) ha^{-1}	32.69ab	43.73a	37.72a	49.16ab	17.06b	22.80a	18.29a	24.55ab
100%PM	32.04ab	42.98a	36.73a	48.61ab	17.68ab	22.92a	18.26a	23.94ab
50%NPK+50%PM	33.28a	44.75a	38.06a	50.65a	18.08a	23.89a	18.66a	26.12a
SE±	0.448	1.127	0.841	0.961	0.293	0.844	0.541	0.864
Variety								
LD88	28.84b	42.15a	30.99b	47.56b	18.25a	25.60a	20.80a	31.79a
NHAE47-4	27.60c	36.18b	30.87b	38.63c	12.72b	15.40c	13.63c	17.13c
Dogo variety	36.16a	43.90a	44.92a	52.61a	18.62a	23.61b	17.65b	20.32b
SE±	0.292	0.739	0.551	0.629	0.192	0.553	0.354	0.566
Interaction								
Fert x Var	*	NS	NS	NS	NS	NS	NS	NS

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT

Table 4. Interaction of variety and fertilizer on plant height at 6WAP during 2017 dry season

	Variety		
Fertilizer	**LD88**	**NHAE47-4**	**Dogo**
Control	25.63d	21.48e	24.61de
800 kg NPK (15:15:15) ha^{-1}	30.33b	28.95cd	38.82ab
100% PM	29.42c	28.64cd	38.05ab
50% NPK+50% PM	31.21b	29.37c	39.26a
SE±	0.775		

Means followed by the same later (s) are not significantly different at 5% level using DMRT

Table 5. Fruit plant^{-1}, fruit mean weight, fruit mean length and fruit yield of okra varieties as influenced by NPK (15:15:15) and poultry manure during 2017/2018 dry season

Treatment	Pods plant^{-1}		Pod mean weight (g)		Pod mean length (cm)		Pod yield (t ha^{-1})	
	2017	2018	2017	2018	2017	2018	2017	2018
Fertilizer								
Control	6.94c	8.98c	9.66c	12.28c	4.48d	4.88c	2.30c	3.22e
800kgNPK (15:15:15) ha^{-1}	14.30a	15.57a	19.11a	21.38a	7.07a	7.91a	6.40a	7.56a
100%PM	13.08b	14.11b	17.59b	19.31b	6.13bc	6.83b	5.65b	6.38c
50%NPK+50%PM	14.13a	15.49a	19.26a	20.86a	6.40b	7.91a	6.40a	7.04b
SE±	0.157	0.813	0.389	0.415	0.214	0.233	0.070	0.110
Variety								
LD88	11.98b	13.06b	14.32c	17.97b	5.97a	7.18a	4.77c	5.31c
NHAE47-4	11.73b	13.82a	19.48a	20.44a	5.40b	5.76b	5.62a	6.80a
Dogo variety	13.12a	13.56a	16.47b	17.55b	6.32a	7.21a	5.28b	5.61b
SE±	0.103	0.173	0.255	0.272	0.140	0.152	0.046	0.073
Interaction								
Fert x Var	*	NS	NS	NS	NS	NS	*	*

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT

by Dogo variety [(5.28 t ha^{-1}) and (5.61 t ha^{-1})] whereas LD88 produced the lowest fruit yield [(4.77 t ha^{-1}) and (5.31 t ha^{-1})]. The highest pod yield was recorded in NHAE47-4 which was significantly higher than the yield produced by Dogo and LD88. This result proved the superiority of the improved cultivars over the local. Jamala et al., [13] had reported a similar observation.

3.2 Response of NPK (15:15:15) and Poultry Manure

There was a significant effect (P<0.05) of fertilization in terms of plant height as observed during 2017/2018 dry seasons (Table 3). In 2017, the height of the plant, in dry season, at 6 WAP, was tallest with the application of 50% NPK+50% PM (33.28 cm) followed by the application of 100% NPK (32.69 cm) and 100% PM (32.04 cm). Shortest plants were recorded by the control (23.90); but at 8 WAP, plant height was similar irrespective of fertilizer levels, except the control, which gave significantly shorter plants (37.39 cm). A similar trend was maintained during 2018 dry season. The increase in plant height resulted from improved soil nutrient, as a result of the combined application of organic manure (poultry manure) with inorganic fertilizer. This finding has buttressed the report of Bairwa [14] that, mineralization of manures aids in soil nutrient buildup that in turn leads to improved nutrient availability to the growing okra.

Results indicated a significant effect (P≤0.05) of fertilization in relation to number of leaves. In 2017 trial, at 6 WAP, application of 50% NPK+50% PM promoted, significantly, the production of more leaves (18.08) than the application of 100% PM (17.68) and 100% NPK (17.06). The lowest number of leaves was by control (12.72). At 8 WAP, all the fertilizer levels gave significantly a similar number of leaves which was higher than the untreated control (15.98). A similar trend was maintained during 2018 trial. The beneficial effect of application of organic manures along with inorganic fertilizers reflected in enhanced vegetative growth of plant. This may be attributed to the synergistic effect of organic manure in making available more plant nutrient by improving the soil physical and chemical condition and solubilising the nutrients. Moreover, organic manures are also significant sources of macro and micronutrients needed by plants [15]. Similar results have been reported by Sharma et al., [16] in okra.

A significant effect (P≤0.05) of fertilisation as regard to number of fruit per plant was observed (Table 5). Application of 50% NPK+50% PM [(14.13) and (15.49)] and 100% NPK [(14.30) and (15.57)] promoted the highest number of fruits in 2017 and 2018 trials respectively followed by application of 100% PM [(13.08) and (14.11)], higher than the control [(6.94) and (8.98)]. This could be attributed to the significant role played by NPK in the improvement of soil fertility, and them, in the enhancement of crop yields. NPK fertilizers have been reported to cause significant effects on fruit weight, fruit number and yield of okra [17]. This also showed that poultry manure was readily available and in the best form for easy absorption by the plant roots, for this there was a boost in the growth of the plant.

There was a significant effect ($P<0.05$) of fertilization in terms of mean fruit weight (g) as observed during 2017/2018 dry seasons (Table 5). Maximum fruit weight was recorded with the application 50% NPK+50% PM [(19.26 g) and (20.86 g)] and 100% NPK [(19.11 g) and (21.38 g)] followed by the application of 100%PM [(17.59 g) and (19.31 g)] in both 2017 and 2018 trials. The minimum fruit weight was obtained from the control [(9.66g) and (12.28 g)]. This observation also agreed with that of Mal et al., [18] who also observed better growth performance of crop with inorganic fertilizers of locally compounded NPK.

Significant effect ($P<0.05$) of fertilization in terms of mean fruit length (cm) was observed during 2017/2018 dry seasons (Table 5). In 2017 trial, highest mean fruit length was obtained from the application of 100% NPK (7.07 cm), while the lowest mean fruit length was recorded by the control (4.48cm). In 2018 trial, plants submitted in application of 100% NPK (7.91 cm) and 50% NPK+50% PM (7.91 cm) presents significantly highest mean fruit length than the application of 100% PM (6.83 CM) which in turn was higher than the control (4.88 cm). This could be attributed to the consistent release of nutrients from both poultry manure and NPK. Similar results have been reported by Sharma et al. [16] in okra.

There was a significant effect ($P<0.05$) of fertilisation in terms of fruit yield (t ha^{-1}) as observed during 2017/2018 dry seasons (Table 5). Application of 50% NPK+50% PM [(6.40 t ha^{-1}) and (7.04 t ha^{-1})] and 100% NPK [(6.40 t ha^{-1}) and (7.04 t ha^{-1})] gave a significantly higher fruit yield in both 2017 and 2018 trials, followed by the application of 100% PM [(5.65 t ha^{-1}) and (6.38 t ha^{-1})] while the control recorded the lowest yield [(2.30 t ha^{-1}) and (3.22 t ha^{-1})]. This could be attributed to the significant role played by NPK in the improvement of soil fertility, nutrient uptake and enhancement of crop yields and poultry manure was readily available and in the best form for easy absorption by the plant roots, hence there is a boost in the growth of the plant. NPK fertilizers have been reported to cause significant effects on fruit weight, fruit number and yield of okra [17].

3.3 Effect of Interaction

Significant interaction effect ($P\leq0.05$) between variety and fertilisation was observed as regards to plant height at 6 WAP during 2017 trial (Table 4). The highest value was obtained with Dogo variety across all the levels of nutrients, while NHAE47-4 in conjunction with the application of 100% NPK and 100% PM, promoted shorter plants. This has clearly indicated the interdependence and complimentary role of fertilization and variety in influencing the manifestation of the potentials of okra cultivars in terms of growth and development as reported by Jamala et al. [13].

Significant interaction effect ($P\leq0.05$) between variety and fertilization was observed on number of pods per plant during 2017 trial (Table 6). The highest number of fruits per plant was obtained from the application of 100% NPK and 50% NPK+50% PM across NHAE47-4 (14.62 and 14.25) and Dogo variety (14.98 and 14.63) while NHAE47-4 in conjunction with the application of 100% PM (12.46) promoted a lower number of fruits per plant. This might be due to quickly mineralized and higher N content of PM and abundant availability of nutrients from both NPK and PM that enhanced the growth and development of okra by increasing the rate of plant metabolic processes like photosynthesis and respiration, which helped to build the plant tissue. Similar results were reported by Olaniyi et al., [10] and Akande et al., [19].

Significant interaction effect ($P\leq0.05$) between variety and fertilization was observed on fruit yield during 2017/2018 trials (Table 7). In 2017 trial, higher fruit yield was obtained after application of 50% NPK+50% PM (7.12 t ha^{-1}) to NHAE47-4 and 100% PM to Dogo variety (5.28 t ha^{-1}). A similar trend was maintained in 2018 trial. The fruit yield generally optimized with the application of NPK+PM at 50:50 ratio and NPK only across all the varieties [20]. This could be due to quick decomposition of PM and consistent release of nutrients by both PM and NPK, leading to higher yield [21].

Table 6. Interaction of variety and fertilizer on pods plant^{-1} during 2017 dry season

	Variety		
Fertilizer	**LD88**	**NHAE47-4**	**Dogo variety**
Control	7.09ef	6.34f	7.39e
800kgNPK(15:15:15) ha^{-1}	13.29bc	14.62a	14.98a
100%PM	12.80c	12.46cd	13.97b
50%NPK+50%PM	13.52b	14.25ab	14.63a
SE±	0.271		

Means followed by the same later (s) are not significantly different at 5% level using DMRT

Table 7. Interaction of variety and fertilizer on yield (t ha^{-1}) during 2017/2018 dry season

	2017		
Fertilizer	Variety		
	LD88	**NHAE47-4**	**Dogo variety**
Control	1.94e	2.07de	2.89d
800kgNPK(15:15:15) ha^{-1}	5.86bc	6.75ab	6.58ab
100%PM	5.45c	6.21b	5.28c
50%NPK+50%PM	5.66bc	7.12a	6.44ab
SE±	0.121		
2018			
Control	2.20f	3.96e	3.51ef
800kgNPK(15:15:15) ha^{-1}	7.48ab	7.96ab	7.24ab
100%PM	6.30bc	7.29ab	5.54d
50%NPK+50%PM	6.76b	8.17a	6.19bc
SE±	0.192		

Means followed by the same later (s) are not significantly different at 5% level using DMRT

4. CONCLUSION

The variety of NHAE47-4 should be combined with the application of 50:50 ratio of NPK and PM for enhanced Okra and other varieties production in the study area.

5. RECOMMENDATION

It is therefore recommended that combination of NPK fertilizer and poultry manure at 50:50 ratios with NHAE47-4 could be adopted for higher Okra fruit yield, considering the complimentary role of poultry manure in improving the structure, chemistry, and biological activity in the soil.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Iyagba AG, Onuegbu BA, Ibe AE. Growth and yield response of okra (*Abelmoschus esulentus* (L.) Moench) to NPK fertilizer rates and weed interference in South-eastern Nigeria. International Research Journal of Agricultural Science and Soil Science. 2013;3(9):328-335.
2. Wamanda DT. Inheritance studies in collected local okra (*Abelmoschus*

esculentus L. Moench) cultivars. In: Combining ability analysis and heterosis on diallel cross of okra. African Journal of Agricultural Research. 2007;5:2108-2155.

3. Rahman K, Waseem M, Kashif MS, Jilani M, Kiran G. Performance of different okra (*Abelmoschus esculentus* L.) cultivars under the agro-climatic conditions of Defra Ismail Khan. Pakistan Journal of Science. 2012;64:316-319.
4. Lee KH, Cho CY, Yoon ST, Park SK. The effect of nitrogen fertilizer, plant density and sowing date on the yield of okra. Korean Journal of Crop Science. 2000;35: 179-183.
5. Saifullah M, Rabbani MG. Evaluation and characterization of okra (*Abelmoschus esculentus* L. Moench.) genotypes. SAARC J Agric. 2009;7:91-98.
6. Kolawole GO, Olapede AO, Alade CR, Olaniyi JO. Response of okra (*Abelmoschus esculentus*) varieties to NPK fertilizer in the South Guinea Savanna of Nigeria. Nigeria Journal of Horticulture. Sci. 2008;13:99-108.
7. Adeleye EO, Ayeni LS, Ojeniyi SO. Effect of poultry manure on soil physico-chemical properties, leaf nutrient contents and yield of yam (*Dioscorea rotundata*) on Afisol soil in South Western Nigeria. Journal of American Science. 2010;6(10):871-878.
8. Singh KV, Anuj K, Kumar M, Soni S, Kumar A, Singh MK. Response of different organic and inorganic fertilizers on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench). Ann. Hort. 2015;8(1):107-109.
9. Onyango CM, Harbinson J, Imungi JK, Shibairo SS, Van Kooten O. Influence of organic and mineral fertilization on germination, leaf nitrogen, nitrate accumulation and yield of vegetable amaranth. Journal Plant Nutrition. 2012; 35(3):342-365.
10. Olaniyi JO, Akanbi WB, Olaniran OA, Ilupeju OA. The effect of organo-mineral and inorganic fertilizers on the growth, fruit yield, quality and chemical composition okra. Journal of Animal and Plant Science. 2010;9(1):1135-1140.
11. Ojo GOS, Richard BI, Jorlamen T. Evaluation of okra (*Abelmoschus esculentus* (L.) Moench) cultivar for dry season ecology of Nigeria. International Journal of Agronomy and Agricultural Research. 2012;3:13-18.
12. Ayoub ZE, Afra AA. Effect of cultivar and sowing date on okra (*Abelmoschus esculentus* (L) Moench) seed yield: Universal Journal of Applied Science. 2014;2(3):64-67.
13. Jamala GY, Boni PG, Abraham P, Musa AM. Soil status and yield response of different varieties of okra (*Abelmoschus esculentus* (L.) Moench) grown at Mubi Floodplain, North Eastern Nigeria. Journal of Agricultural Biotechnology and Sustainable Development. 2011;3(7):120-125.
14. Bairwa HL, Shukla AK, Mahawer LN, Kaushik RA, Shukla KB, Ameta KD. Response of integrated nutrient management on yield, quality and physico-chemical characteristics of okra cv. Arka Anamika. Indian Journal of Horticulture. 2009;66(3):310-314.
15. Tyagi SK, Shukla A, Mittoliya VK, Sharma ML, Khire AR, Jain YK. Effect of integrated nutrient management on growth yield and economics of okra under nimar valley condition of Madhya Pradesh. International Journal of Tropical Agriculture. 2016;34(2): 415-419.
16. Sharma IJ, Samnotra RK, Kumar V, Rai AP, Dhotra B. Effect of organic and inorganic fertilizers on the growth and yield of okra under sub-tropical region. Ann. Plant and Soil Res. 2015;17(2):215-218.
17. Sarkar S, Singh SR, Singh RP. The effect of organic and inorganic fertilizer on soil physical condition and the productivity of rice-lentil cropping sequence in India. Journal of Agricultural Science. 2003; 140(4):419-425.
18. Mal B, Mahapatra P, Mohanty S, Mishra HN. Growth and yield parameters of okra (*Abelmoschus esculentus*) influenced by diazotrophs and chemical fertilizers. Journal of Crop and Weed. 2013;9(2):109-112.
19. Akande MO, Oluwatoyinbo EA, Makinde E. A, Adepoju AS, Adepoju IS. Response of okra to organic and inorganic fertilization. Journal of Natural Science. 2010;8(11): 261–266.
20. Prasad PH, Naik A. Effect of varying NPK levels and bio-fertilizers on growth and yield of okra [*Abelmoschus esculentus* (L.)

Moench] under sustainable condition. Journal of Bioscience. 2013;6(2):167-169.

21. Kumar A, Pal AK, Mauriya SK, Yadav KS. Pal SK. Effect of different doses of NPK and various bio-fertilizers on floral characters and yield attributes in okra, Int. J. Pure App. Biosci. 2018;6(2):352-356.

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