Research Article

Journal of Agriculture and Horticulture Research

# Response of Okra (*Abelmoschus esculentus* L. Moench) Varieties to Sole and Combined Organic and Inorganic Fertilization in the Sudan Savanna Ecological Zone of Kebbi state

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**Submitted**: 07 Dec 2018; **Accepted**: 15 Dec 2018; **Published**: 20 Dec 2018

## Abstract
*Field experiments were conducted in two locations at the University Teaching and Research Farms during 2016/2017 dry season. The two locations were: Fadama Teaching and Research farm at Jega (lat. 12°12.99' N; long. 4° 21.90'; 197m above sea level) and the University orchard at Aliero (lat. 12°18.64'N; long. 4°29.85'; 262 above sea level). Both Jega and Aliero are located within Sudan Savanna ecological zone of Nigeria. The aim was to determine the response of Okra (Abelmoschus Esculentus L. Moench) Varieties to sole and combined application of organic and inorganic fertilizer. The treatments consisted of factorial combination of three Okra varieties (LD 88, NHAE47-4 and Dogo variety) and six (6) fertilizers levels, each designed to supply the recommended dosage of 120 kg N ha$^{-1}$ using a compound fertilizer NPK [15:15:15], poultry manure and cow dung. Results revealed that growth and yield parameters such as plant height (8WAP), number of branches (8WAP), number of pods per plant, pod mean weight (g), pod mean length (cm) and fresh pod yield (ha$^{-1}$) were significantly increased when the recommended nitrogen dose of 120kgNha$^{-1}$ was applied using 100% NPK (800kg NPK [15:15:15/ha]) or a combination of NPK and PM at 50:50 ratio in conjunction with NHAE47-4. Based on the results of this study, it was concluded that the integration of organic and inorganic fertilizer in form of NPK compound fertilizer and poultry manure combination at 50:50 ratio in conjunction with NHAE47-4 could be adopted for higher Okra pod yield, considering the complimentary role of poultry manure in improving the physical quality of the soil.*

**Keywords:** NPK fertilizer, Poultry manure, Cow dung, Varieties, Okra pod yield

## Introduction
Okra (*Abelmoschus esculentus* (L.) Moench) is an important vegetable crop consumed worldwide. It is a member of the Malvaceae family. The crop is widely cultivated in the tropics and subtropics for its immature edible green fruits which are consumed as a vegetable [1]. It is a common ingredient of soups and sauces. The fruits can be conserved by drying or pickling. The leaves from the crop are sometimes used as a substitute for spinach [2]. It has a great demand because it forms an essential part of human diet. It is grown mainly for its young tender fruits and can be found in most markets in Africa [3]. Okra is a vegetable of national importance in Nigeria as it is rich in vitamins and minerals. 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 such as tuwonshinkafa, eba, amala, akpu, pounded yam, etc. Its importance ranked above most other vegetables including cabbage, amaranths, and lettuce [4]. According to FAOSTAT (2016), Global production for okra approximately stands at 8,900,434 million tons grown on 2,157,961 hectares. The major producing countries include India (5,507,000 tons), Nigeria (1,978,286 tons), Sudan (287,000 tons), Mali (241,033), Pakistan (117,961 tons), Cote d'Ivoire (112,966 tons), Ghana (66,360 tons), Egypt (55,166 tons), Iraq (123,583 tons), and Malaysia (55,856 tons) as at 2016 [5]. Nutritionally, tender green pods of okra are important sources of vitamins and minerals such as vitamins A, B1, B3, B6, C and K, folic acid, potassium, magnesium,

calcium and trace elements such as copper, manganese, iron, zinc, nickel, and iodine (Lee et al., 2000), which are often lacking in the diet of people in most developing countries. On the average, young green pod contains 86.1% moisture, 9.7% carbohydrate, 2.2% protein, 0.2% fat, 1.0% fiber and 0.8% ash [6].

Organic fertilizers provide nutrients and contribute to the quality of soil by improving the structure, chemistry, and biological activity in the soil. They are known for their gradual release of nutrients, and improvement of soil organic matter content [7]. However, decomposition of organic material and release of nutrients from it is strongly affected by temperature and soil moisture content [8]. This implies that nutrients may be released when the conditions are favorable and perhaps when plants do not need them. Due to the low nutrient content of organic fertilizers, coupled with limited availability of organic material in many regions, it is generally difficult to meet the crop nutrient demands with sole organic fertilizers [9]. In inorganic fertilizers, nutrients content are relatively high and they rapidly supply nutrients directly because they do not have to undergo decomposition processes like the organic fertilizers. This made it possible to predict, to some extent, the level and timing of nutrient uptake by crop. However, inorganic fertilizers are known for their high cost and their negative environmental effect if not managed properly [10,11].

Considering the cost, unavailability at the time needed and environmental pollution effects of inorganic fertilizer as well as the gradual release of nutrient and limited amount of organic materials in many regions, there is need to look for alternative ways of improving soil fertility at a reasonable affordable and environmentally safe while striving to increase crop yield and sustained soil productivity [12]. Combined use of organic and Inorganic fertilizer reduced cost and amount of fertilizer required by crops [13]. According to Onyango et al. (2012) the combined application of organic and chemical fertilizers is gradually recognized as a feasible way to address soil fertility decline in some places [14]. According to Olatunji and Ayuba (2012), since almost all attempts made to maintain continuous crop production with inorganic fertilizer alone in Nigeria have failed, the need to evolve production systems that will utilize the combined use of organic and inorganic fertilizers for improving crop productivity in Nigeria cannot be over-emphasized [15,16].

This research work is carried out to identify an ideal variety and possible integration of organic and inorganic fertilizer that will give optimum okra yield which will in turn meet the demand of the growing population.

## Materials and Methods

The research was conducted at the University Teaching and Research Farms during 2017/2018 dry season. The two locations were: Fadama Teaching and Research farm at Jega (lat. 12°12.99' N; long. 4° 21.90'; 197m above sea level) and the University orchard at Aliero (lat. 12°18.64'N; long. 4°29.85'; 262 above sea level). Both Jega and Aliero are located at in Sudan Savanna ecological zone of Nigeria.The treatments consist of three (3) okra varieties (LD 88, NHAE47-4 and Dogo variety) and six (6) levels of fertilizers, each will be designed to supply the recommended nitrogen dose of 120 kg N $ha^{-1}$ using compound fertilizer NPK (15:15:15), cow dung (CD) and poultry manure (PM). The level of fertilizers are; 800kg NPK (15:15:15) $ha^{-1}$, 100% CD $ha^{-1}$ equivalent to 12 t $ha^{-1}$, 100% PM $ha^{-1}$ equivalent to 6.6 t $ha^{-1}$, 50% CD plus 50% PM $ha^{-1}$ (6 t of CD + 3.3 t of PM $ha^{-1}$), 50% NPK plus 50% CD $ha^{-1}$ (400kg of NPK [15:15:15] + 6 t of CD $ha^{-1}$), and 50% NPK plus 50% PM $ha^{-1}$ (400kg of NPK [15:15:15] + 3.3 t of PM $ha^{-1}$) and the untreated controldenoted as V1, V2 and V3 for varieties and N0, N1, N2, N3, N4, N5, and N6, respectively for levels of nutrients.

The two sites were ploughed and harrowed to obtain good tilt. The lands were leveled 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 3 x 2.5m (7.5$m^2$). Space measuring 1.5m was left between blocks and 0.5m between plots. The nursery was prepared by ploughing using a hand hoe. Organic manures (Poultry manure and Cow dung) was then applied evenly into the nursery bedaccording to treatment in order to improve its fertility status and then watered. The nursery left for 5 days with daily watering to stimulate the release the nutrients from manure applied.

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. Application of NPK (15:15:15) was done in 2 split doses according to treatment. The first dose was applied at 2 WAP and the second dose was applied at 5 WAP.Weeding was carried out manually using hand hoe at 3 and 6 WAP and occasional hand pulling when necessary to ensure weed free plots.Data were recorded on plantheight, number of branches per plant, number of pods per plant, pod mean weight Pod mean length, and Pod Yield. 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.

## Results and Discussion

### Varietal Response

The differences observed among the three varieties (LD88, NHAE47-4 and Dogo variety) could be attributed to their genetic make-up. Ayoub et al. (2014) affirmed that differential growth of crops under similar environmental conditions is normally the result of differences in the genetic make-up of these crops [17]. Results revealed significant effect ($P \le 0.05$) of variety on plant height at 8WAP in both locations (Table 3). Variety Dogowas the tallest owing to its characteristic taller statue compared to the other varieties. Ojo et al. (2012) in their research reported that, okra variety Dogowas taller than many improved varieties, a phenomenon peculiar to local okra cultivars [18]. Significant effect ($P \le 0.05$) of variety was observed as regard to the number of branches. Highest number of branches per plantwas observed in LD88 at all growth stages followed by NHAE47-4 which in turn was higher than Do go variety (Table 4). This in line with the report by Jamala et al. (2011), where they reported lowest number of branches with local okra variety [19]. The differential performance of the cultivars to height and branches may have been influenced by their unique genetic characteristics. These results are supported by previous works of Rahman et al. (2012) [3].

**Table 1: Physical and Chemical Properties of Soil of the Experimental sites at Aliero and Jega during 2017/2018 dry session**

| | Aliero | Jega |
|---|---|---|
| | 0–30cm depth | |
| Particles size Analysis | | |
| pH | 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 Cow dung (CD) and Poultry manure (PM)**

| Character | Cow dung | Poultry manure |
|---|---|---|
| Organic carbon (g $kg^{-1}$) | 4.13 | 3.26 |
| PH | 7.6 | 6.2 |
| Total N (mg $kg^{-1}$) | 1.02 | 1.83 |
| Na (mg $kg^{-1}$) | 155 | 140 |
| K (mg $kg^{-1}$) | 3800 | 2500 |
| Ca (mg $kg^{-1}$) | 0.85 | 0.55 |
| P (mg $kg^{-1}$) | 4.51 | 8.04 |

Significant effect (P<0.05) of variety was observed as regards to number of pods per plant (Table 4). At Aliero and combined trial, higher number of pods per plant recorded by Dogo, followed by NHAE47-4 and LD88 which were similar but in Jega trial, Dogo and NHAE47-4 produced significant similar number of pods per plant which in turn were higher than LD88. This result corroborates the earlier reports of Rahman et al. (2012) who also had significant effect of number of podsper plantin different okra cultivars. Significant effect (P<0.05) of variety was observed as regards to pod weight (Table 3) [3]. At Aliero trial, NHAE47-4 produced significantly heavier pod than Dogo which in turn were heavier than LD88 but at Jega and combined trials, NHAE47-4 produced significantly heavier pod than Dogo and LD88 which were similar. Khan et al. (2002) and Rahman et al. (2012) also recorded significant effect of cultivar on single pod weight [3,20]. This result is in accordance with the findings of Ojo et al. (2012), who observed that Dogo variety produces lighter pods compared to NHAE47-4 [18]. Significant effect (P≤0.05) of variety as regard to mean pod length was observed among the varieties (Table 4). Dogo variety and LD88 recorded the higher pod length whereas NHAE47-4 had the lowest in all the trials. This result disagree with the findings of Jamala et al. (2011) in their work with local andImproved varieties of okra where they reported that local variety had the shortest pod length [19]. Significant effect (P≤0.05) of variety as regards to pod yield of okra was observed (Table 4). NHAE47-4 produced significantly higher yield than Dogo which were in turn produced slightly more yield than LD88 (Table 5). The result also showed that Dogo variety and LD88 had intermediate performance, but altogether were statistically not different. This result proved the superiority of the improved cultivars over the local. Jamala et al. (2011) had reported a similar observation [19]. This result appears to support the hypothesis that early flowering may have conferred NHAE47-4 a better opportunity for early and longer fruit setting period which consequently influenced its yielding advantage over the others. This observation is in line with the reports of other researchers who also found highest pod yield in plots that flowered earliest and also had the highest pods per plant [3,20].

**Table 3: Plant height and number of leaves as influenced by variety and organic and inorganic fertilization in Aliero, Jega and the combined mean during 2017/2018 dry season**

| Treatment | Plant Height (cm) 8WAP | | | Number of Branches 8WAP | | |
|---|---|---|---|---|---|---|
| | Aliero | Jega | Combined | Aliero | Jega | Combined |
| **Fertilizer** | | | | | | |
| Control | 27.39b | 32.64c | 30.02b | 1.47b | 1.99c | 1.73b |
| 800kgNPK (15:15:15) ha-1 | 43.73a | 49.16ab | 46.45a | 1.92a | 3.03a | 2.47a |
| 100%CD | 42.02a | 47.48b | 44.75a | 1.82a | 2.66b | 2.24a |
| 100%PM | 42.98a | 48.61ab | 45.80a | 1.96a | 3.05a | 2.51a |
| 50%CD+50%PM | 42.14a | 47.56b | 44.85a | 1.78a | 2.43b | 2.11ab |
| 50%NPK+50%CD | 42.24a | 47.76ab | 45.00a | 1.85a | 2.59b | 2.22a |
| 50%NPK+50%PM | 44.75a | 50.65a | 47.70a | 1.99a | 3.09a | 2.54a |
| **SE±** | **1.127** | **0.961** | **1.070** | **0.084** | **0.119** | **0.164** |
| **Variety** | | | | | | |
| LD88 | 42.15a | 47.56b | 44.86b | 1.99a | 3.78a | 2.89a |
| NHAE47-4 | 36.18b | 38.63c | 37.41c | 1.76b | 2.41b | 2.08b |
| Dogo variety | 43.90a | 52.61a | 48.26a | 1.72b | 1.89c | 1.81b |
| SE± | 0.739 | 0.629 | 0.701 | 0.055 | 0.078 | 0.108 |
| **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

**Table 4: Number of pods per plant, pod mean weight, pod mean length and yield as influenced by variety and organic and inorganic fertilization in Aliero, Jega and the combined mean during 2017/2018 dry season**

| Treatment | Pods Plant-1 | | | Pod mean weight (g) | | | Pod mean length (cm) | | | Yield (t ha-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aliero | Jega | Combined | Aliero | Jega | Combined | Aliero | Jega | Combined | Aliero | Jega | Combined |
| **Fertilizer** | | | | | | | | | | | | |
| Control | 6.94d | 8.98d | 7.96d | 9.66c | 12.28c | 10.97c | 4.48d | 4.88c | 4.68c | 2.30e | 3.22f | 2.76d |
| 800kgNPK (15:15:15) ha-1 | 14.30a | 15.57a | 14.93a | 19.11a | 21.38a | 20.25a | 7.07a | 7.91a | 7.49a | 6.40a | 7.56a | 6.98a |
| 100%CD | 12.30c | 13.36bc | 12.83bc | 16.72b | 18.56b | 17.64b | 5.54c | 6.47b | 6.00bc | 4.99d | 5.89d | 5.44c |
| 100%PM | 13.08b | 14.11b | 13.59b | 17.59b | 19.31b | 18.45b | 6.13bc | 6.83b | 6.48b | 5.65b | 6.38c | 6.00b |
| 50%CD+50%PM | 12.28c | 13.24c | 12.76c | 17.40b | 18.99b | 18.20b | 5.73c | 6.57b | 6.15bc | 5.22c | 5.48e | 5.35c |
| 50%NPK+50%CD | 12.90b | 13.62bc | 13.26bc | 17.59b | 19.18b | 18.39b | 5.92bc | 6.81b | 6.36b | 5.58b | 5.81d | 5.70bc |
| 50%NPK+50%PM | 14.13a | 15.49a | 14.81a | 19.26a | 20.86a | 20.06a | 6.40b | 7.91a | 7.16a | 6.40a | 7.04b | 6.72a |
| **SE±** | **0.157** | **0.813** | **0.269** | **0.389** | **0.415** | **1.769** | **0.214** | **0.233** | **0.199** | **0.070** | **0.110** | **0.146** |
| **Variety** | | | | | | | | | | | | |
| LD88 | 11.98b | 13.06b | 12.52b | 14.32c | 17.97b | 16.15b | 5.97a | 7.18a | 6.58a | 4.77c | 5.31c | 5.04c |
| NHAE47-4 | 11.73b | 13.82a | 12.77b | 19.48a | 20.44a | 19.96a | 5.40b | 5.76b | 5.58b | 5.62a | 6.80a | 6.21a |
| Dogo variety | 13.12a | 13.56a | 13.34a | 16.47b | 17.55b | 17.01b | 6.32a | 7.21a | 6.76a | 5.28b | 5.61b | 5.44b |
| **SE±** | **0.103** | **0.173** | **0.176** | **0.255** | **0.272** | **1.159** | **0.140** | **0.152** | **0.131** | **0.046** | **0.073** | **0.096** |
| **Interaction** | | | | | | | | | | | | |
| **Fert x Var** | * | NS | NS | 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 5: Interaction of Variety and Fertilizer on Number of Branches at 8WAP for Jega location during 2017/2018 dry season**

| | Variety | | |
|---|---|---|---|
| **Fertilizer** | **LD88** | **NHAE47-4** | **Dogo variety** |
| Control | 2.58c | 1.87d | 1.51d |
| 800kgNPK (15:15:15) ha-1 | 4.55a | 2.52c | 2.01cd |
| 100%CD | 3.79b | 2.25c | 1.94d |
| 100%PM | 4.43a | 2.69c | 2.03cd |
| 50%CD+50%PM | 3.43b | 2.20c | 1.65d |
| 50%NPK+50%CD | 3.48b | 2.27c | 2.02cd |
| 50%NPK+50%PM | 4.20a | 3.04bc | 2.04cd |
| SE± | 0.206 | | |
| Means followed by the same later (s) are not significantly different at 5% level using DMRT | | | |

## Response to Fertilization

Significant effect ($P<0.05$) of fertilization in terms of plant height as observed in all trials (Table 3). In Aliero and combined trials, plant height was similar by all fertilizer levels except the untreated control which gave the significantly shorter plants but in Jega trial, application of each combined application of NPK and PM at 50:50 ratiosrecorded the taller plants than the application of 100% CD which in turn were significantly taller than the untreated control. This finding was buttressed the report of Bairwa (2009) that, mineralization of manures aids in soil nutrient buildup that in turn leads to improved nutrient availability to the growing okra [21]. The treatments with sole (100%) application of NPK, sole (100%) PM and the combined application of NPK and PM at 50:50 ratio has registered maximum number branches (Table 4). Similar findings have been reported by Yadav et al. (2006), Prasad and Naik (2013) and Sharma et al. (2015) [13,22,23]. 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, the organic manures are also significant sources of major and micronutrients much needed by plants [24]. Similar results have been reported by Sharma et al. (2015) in okra [23]. The significant positive yield response of okra varieties to organo-mineral fertilization is a confirmation of the essentiality of nutrients for the overall performance of okra. All the yield characters such as number of pods per plant, mean pod length, mean pod diameter, mean pod weight, fresh pods weight per plant and yield per hectare were peaked with the application of NPK and PM at 50:50 ratio and application of NPK alone could be attributed to the significant role played by NPK in the improvement of soil fertility, nutrient uptake and enhancement of crop yields. NPK fertilizers have been reported to cause significant effects on fruit weight, fruit number and yield of okra [7]. This also shows that 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. High values in mean pod length and mean pod diameter were observed with the application of NPK+PM at 50:50 ratio and NPK sole.This could also be attributed to the role of applied NPK in enhancing production of assimilates during growth and consequent partitioning of these assimilates to pods. Dademal et al. (2004) and Omotosho and Shittu (2007) reported that higher NPK fertilizer dosesresulted to increase in the uptake of N, P and K nutrients [25]. Most of the yield and yield components were positively enhanced with sole NPK and with combination with PM at 50:50 ratio. Similar findings were reported by Yadav et al. (2006), Olaniyi et al. (2010) and Prasad and Naik (2013) [4,13,22].

**Table 6: Interaction of Variety and Fertilizer on Pods plant-1 for Aliero location during 2017/2018 dry season**

| | Variety | | |
|---|---|---|---|
| **Fertilizer** | **LD88** | **NHAE47-4** | **Dogo variety** |
| Control | 7.09f | 6.34g | 7.39f |
| 800kgNPK (15:15:15) ha-1 | 13.29bc | 14.62a | 14.98a |
| 100%CD | 12.00d | 11.46de | 13.43bc |
| 100%PM | 12.80c | 12.46cd | 13.97b |
| 50%CD+50%PM | 12.21cd | 11.13e | 13.50bc |
| 50%NPK+50%CD | 12.96c | 11.85de | 13.90b |
| 50%NPK+50%PM | 13.52bc | 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) for Aliero and Jega location during 2017/2018 dry season**

| **Fertilizer** | **Aliero** | | |
|---|---|---|---|
| | **LD88** | **NHAE47-4** | **Dogo variety** |
| Control | 1.94f | 2.07ef | 2.89e |
| 800kgNPK(15:15:15) ha-1 | 5.86bc | 6.75ab | 6.58ab |
| 100%CD | 4.18d | 5.73bc | 5.09cd |
| 100%PM | 5.45c | 6.21b | 5.28cd |
| 50%CD+50%PM | 4.75d | 5.55c | 5.37c |
| 50%NPK+50%CD | 5.52c | 5.92bc | 5.29cd |
| 50%NPK+50%PM | 5.66bc | 7.12a | 6.44ab |
| SE± | 0.121 | | |
| Jega | | | |
| Control | 2.20f | 3.96e | 3.51ef |
| 800kgNPK (15:15:15) ha-1 | 7.48ab | 7.96a | 7.24ab |
| 100%CD | 4.71de | 6.52bc | 6.42bc |
| 100%PM | 6.30bc | 7.29ab | 5.54cd |
| 50%CD+50%PM | 4.63de | 6.61bc | 5.20cde |
| 50%NPK+50%CD | 5.11d | 7.13b | 5.20cde |
| 50%NPK+50%PM | 6.76bc | 8.17a | 6.19c |
| SE± | 0.192 | | |
| Means followed by the same later (s) are not significantly different at 5% level using DMRT | | | |

## Interaction

The significant response of, number of pods per plant and pod yield to the interaction of variety and organic to and organic fertilization (Table 5, 6 and 7) have 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, development and yield as reported by Jamala et al. (2011). LD88 attained higher growth in terms of plant height, number of leaves, branches and earliest days to flowering with the application of NPK+PM at 50:50 ratio and NPK sole. NHAE47-4 attained higher plant height and number of branches with the application of NPK+PM at 50:50 ratio while earliest days to flowering was attained with application of sole PM [19]. Dogo variety attained similar performance with the application of NPK+PM at 50:50 ratio. This might be due to quick decomposed and higher nitrogen 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 in turn helped to build the plant tissue. Similar result was reported by Olaniyi et al., (2009) and Akande et al. (2010) [4]. The yield characters such as number of pods per plant, mean pod diameter and pod yield were generally optimized with the application of NPK+PM at 50:50 ratio and NPK sole across all the varieties. This could be due to quick decomposed of PM and consistent release of nutrients by both PM and NPK, leading to higher yield [22,26-29].

## Conclusion

Based on the results of this study, it can be concluded that the variety NHAE47-4 has been demonstrated to give higher yield than Dogo and LD88 in both the two locations. The general performance of variety NHAE47-4 was shown to be better across all treatments in the two locations of the study. Among the nutrient levels combination of NPK and PM at 50:50 ratios resulted in the higher growth and yield attributes of okra.

## 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 pod yield, considering the complimentary role of poultry manure in improving the structure, chemistry, and biological activity in the soil.

## References


1. Iyagba AG, Onuegbu BA, Ibe AE (2013) 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 3: 328-335.
2. Singh B, Aakansha G (2014) Correlation and path coefficient analysis in okra (*Abelmoschus esculentus*). Indian J Agric Sci 84: 1262-1266.
3. Rahman K, Waseem M, Kashif M S, Jilani M, Kiran G (2012) Performance of different okra (*Abelmoschus esculentus* L.) cultivars under the agro-climatic conditions of Defra Ismail Khan. Pakistan Journal of Science 64: 316-319.
4. Kolawole GO, Olapede AO, Alade CR, Olaniyi JO (2008) Response of okra (*Abelmoschus esculentus*) varieties to NPK fertilizer in the South Guinea Savanna of Nigeria. Nigeria Journal of Horticulture 13: 99-108.
5. FAOSTAT data (food and agricultural organization statistic), (2016) http://www.fao.org.
6. Saifullah M, Rabbani MG (2009) Evaluation and characterization of okra (*Abelmoschus esculentus* L. Moench.) genotypes. SAARC J Agric 7: 91-98.
7. Sarkar S, Singh SR, Singh RP (2003) 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 140: 419-425.
8. Adekiya AO, Ojeniyi SO, Agbede MT (2012) Poultry manure effects on soil properties, leaf nutrient status, growth and yield of cocoyam in a tropical Alfisol. Nigerian Journal of

Soil Science 22: 30-39.
9. Eneje RC, Uzoukwu I (2012) Effect of rice mill waste and poultry manure on some soil chemical properties, growth and yield of maize.Nigerian Journal of Soil Science 22: 59-60.
10. Saidu A, Bello LY, Tsado EK, Sani A (2011) Influence of varied rates of poultry dropping on the growth and yield performances of Tomato (*Lycopersicum Esculeutum* L.) Cultivars. Proceeding of 26th annual conference of horticultural society of Nigeria. 24 – 29th July, 2011. Uni. Of Agriculture, Makurdi, B/State.
11. Aisha AH, Rizk FA, Shaheen, AM ,Abdel-Mouty MM (2007) Onion plant growth, bulbs yield and its physical and chemical properties as affected by organic and natural fertilization. Research Journal of Agriculture and Biological Sciences 3: 380-388.
12. Olatunji O, Oboh VU (2012) Growth and yield of Okra and Tomato as affected by Pig dung and other manure issue for Economic Consideration in Benue state. In: Nigerian Journal of Soil Science 22: 103-107.
13. Prasad PH, Naik A (2013) Effect of varying NPK levels and bio-fertilizers on growth and yield of okra [*Abelmoschus esculentus* (L.)Moench] under sustainable condition. Journal of Bioscience 6: 167-169.
14. Onyango CM, Harbinson J, Imungi J K, Shibairo S S, Van Kooten O (2012) Influence of organic and mineral fertilization on germination, leaf nitrogen, nitrate accumulation and yield of vegetable amaranth. Journal Plant Nutrition 35: 342-365.
15. Olatunji O, Ayuba SA (2012) Effect of combined applications of poultry manure and NPK 20-10-10 fertilizer on soil chemical properties and yield of maize (*Zea mays* L.). Proceedings of the 35th Annual Conference of the Soil Science Society of Nigeria (SSSN). 7th-11th March, 2011, Federal University of Technology Minna.
16. Olatunji SO, Ayuba SA, Anjembe BC, Ojeniyi SO (2012) Effect of NPK and Poultry manure on Cowpea and Soil nutrient composition. Nigerian Journal Journal of Science 22: 108-113.
17. Ayoub ZE, Afra AA (2014) Effect of cultivar and sowing date on okra (*Abelmoschus esculentus* (L) Moench) seed yield: Universal Journal of Applied Science 2: 64-67.
18. Ojo GOS, Richard BI, Jorlamen T (2012) Evaluation of Okra (*Abelmoschus esculentus* (L.)Moench) cultivar for dry season ecology of Nigeria. International Journal of Agronomy and Agricultural Research 2: 13-18.
19. Jamala GY, Boni PG, Abraham P, Musa AM (2011) 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 3: 120-125.
20. Khan FA, Din JU, Ghaffoor A, Khan KW (2002) Evaluation of different cultivars of okra (*Abelmoschus esculentus* L.) under the Agro- climatic conditions of Dera Ismail Khan. Asian Journal of Plant Science 1: 663-664.
21. Bairwa HL, Shukla AK, Mahawer LN, Kaushik RA, Shukla KB, et al. (2009) Response of integrated nutrient management on yield, quality and physico-chemical characteristics of okra cv. ArkaAnamika. Indian Journal of Horticulture 66: 310-314.
22. Yadav P, Singh P, Yadav RL (2006) Effect of organic manures and nitrogen levels on growth, yield and quality of okra. Indian Journal of Horticulture 63: 215-217.
23. Sharma IJ, Samnotra RK, Kumar V, Rai AP, Dhotra B (2015) Effect of organic and inorganic fertilizers on the growth and yield of okra under sub-tropical region. Ann Plant and Soil Res 17: 215-218.
24. Tyagi SK, Shukla A, Mittoliya VK, Sharma ML, Khire AR, et al. (2016) Effect of integrated nutrient management on growth yield and economics of okra under nimar valley condition of Madhya Pradesh. International Journal of Tropical Agriculture 34: 415-419.
25. Omotosho SO, Shittu OS (2007) Effect of NPK fertilizer rates and method of application on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench). Res J Agron 1: 84-87.
26. Lee KH, Cho CY, Yoon ST, Park SK (2000) The effect of nitrogen fertilizer, plant density and sowing date on the yield of okra. Korean Journal of Crop Science 35: 179-183.
27. Mal B, Mahapatra P, Mohanty S, Mishra HN (2013) Growth and yield parameters of okra (*Abelmoschus esculentus*) influenced by diazotrophs and chemical fertilizers. Journal of Crop and Weed 9: 109-112.
28. Naeem M, Iqbal J, Bakhsh A (2006) Comparative Study of Inorganic Fertilizers and Organic Manures on Yield and Yield Components of Mungbean (*Vigna radiat* L.). Journal of Agriculture and Social Sciences 2: 227-229.
29. Singh KV, Anuj K, Kumar M, Soni S, Kumar A, et al. (2015) Response of different organic and inorganic fertilizers on growth and yield of okra (*Abelmoschus esculentus* (L.) Moench). Ann Hort 8: 107-109.