

Response Of Okra (*Abelmoschus esculentus* L.) To The Integrated Application Of NPK, Desert Lion Foliar And Urea Fertilizers

Respon Okra (*Abelmoschus esculentus* L.) Terhadap Aplikasi Pupuk NPK, *Desert Lion Foliar* Dan Urea

Aggrey, H^{1*}), Osei M.K¹⁾, Sarkodie Addo J²⁾, Kojo K.Y, Keteku A¹⁾, Dormatey R¹⁾, Danquah E.O¹⁾, Osei Asante M.O¹⁾ & Ghanney P¹⁾

¹⁾CSIR-Crops Research Institute, Box 3785, Kumasi, Ghana

²⁾Department of Crop and soil Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

email: *habbibahaggrey@gmail.com

ABSTRACT

A field trial was conducted at CSIR-Crops Research Institute, Kumasi, from April to August 2020 to investigate the effect of NPK 15:15:15 at 50:30:30 kg ha⁻¹, Desert-Lion foliar fertilizer 8%, N:6%, Ca:1%, Mg (DL) at 25ml/15 l water, Urea at 50kg ha⁻¹, P₂O₅ and K₂O at 30kg/ha Desert-lion foliar fertilizer at 25ml/15 l water (DPK) and P₂O₅ and K₂O at 30kg/ha urea at 50kg/ha Desert-lion foliar fertilizer at 25ml/15 l water (DPKU) on the performance of okra. A randomized complete block design was used with four replications. Data were collected on growth and yield components. ANOVA was performed using GenStat 15th edition at 5% level of significance. The DPKU, DPK, sole urea and NPK exhibited superior performances in plant height, leaf and branch per plant compare with the sole DL and the control. The DPKU, DPK, NPK and sole urea recorded 40, 39, 38 and 37 fruits per plant respectively, compared to 23 and 35 registered by sole DL and the control respectively. The NPK, DPKU, DPK and sole urea recorded significant total fruit yields of about 7,5t/ha; 7,5t/ha; 6,5t/ha and 6t/ha respectively, which were significantly higher than the 2,5t/ha of the sole DL and the 1,5t/ha of control. The treatment combinations, sole Urea and NPK performed higher than the sole DL. Therefore, for high yield of okra, the DL at 25ml/15 liters of water should be applied with basal application of 30kg/ha of P₂O₅ and K₂O + urea at 50kg/ha at flowering.

Key Words: *Desert-lions foliar fertilizer, NPK, Okra, Productivity, Urea*

ABSTRAK

Uji coba lapangan dilakukan untuk mengetahui pengaruh NPK 15:15:15 pada 50:30:30 kg ha⁻¹, pupuk daun (DL) Desert-Lion pada 25ml/15 l air, Urea pada 50kg ha⁻¹, P₂O₅ dan K₂O pada 30kg ha⁻¹ + Pupuk daun singa gurun pada 25ml/15 l air (DPK) dan P₂O₅ dan K₂O pada 30 kg/ha urea pada 50kg/ha pupuk daun singa gurun pada 25ml/15 l air (DPKU) terhadap kinerja okra. Rancangan acak kelompok lengkap digunakan dengan empat ulangan. Data dikumpulkan pada komponen pertumbuhan dan hasil. DPKU, DPK, urea tunggal dan NPK menunjukkan kinerja unggul dalam tinggi tanaman, daun dan cabang per tanaman dibandingkan dengan DL tunggal dan kontrol. DPKU, DPK, NPK dan urea tunggal mencatat masing-masing 40, 39, 38 dan 37 buah per tanaman, dibandingkan dengan 23 dan 35 yang didaftarkan oleh DL tunggal dan kontrol masing-masing. NPK, DPKU, DPK dan urea tunggal mencatat hasil buah total yang signifikan masing-masing sekitar 7,5t/ha; 7,5t/ha; 6,5t/ha dan 6,0t/ha, sementara DL tunggal dan kontrol menghasilkan 2,5t/ha dan 1,5t/ha menghasilkan masing-masing. Kombinasi perlakuan Urea tunggal dan NPK memiliki kinerja yang lebih tinggi dibandingkan DL tunggal. Oleh karena itu, untuk menghasilkan okra yang tinggi, DL pada 25ml/15 liter air harus diterapkan dengan aplikasi dasar 30kg/ha P₂O₅ dan K₂O + urea pada 50kg/ha saat pembungaan.

Kata Kunci: *Pupuk Daun Singa, NPK, Okra, Produktivitas, Keberlanjutan, Urea*

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a great vegetable with several variety of promising health advantages and quality of nutrition (Aderemi & Sangodoyin, 2019). The pods of okra contain mucilaginous substance which is effective for the replacement of blood plasma or the expansion of the volume of blood. It has been reported that okra has some curative advantage against prolonged dysentery, genito-urinary infections and spermatorrhoea (Devanda *et al.*, 2021). However, the emergence of seedlings, plant growth, development and yields of vegetables including okra are noted to be greatly influenced by the nutritional states of the growth media (Majekodunmi *et al.*, 2021).

It is established that synthetic fertilizers play important functions in soil nutrition improvement and boosting of the yields of crops. Their use remains important due to the inadequacies of land and soils' qualities coupled with the overwhelming growing demands for agricultural commodities to (Majekodunmi *et al.*, 2021). Fertilizer positively influences crops growth to optimize yield. It is well noted that right amount of fertilizer is a key requirement for optimum crop growth as it greatly influences development and seed production (Majanbu, Ogunlela, Abmed & Olarewaju, 1985). Crop producers have adopted inorganic fertilizer widely as a result of it being easy to handle, convenience in storage and carting. Again, the composition of the mineral fertilizer has been established and this makes the determination of appropriate rate and time of application easy, and to guide in

projecting the precision of the influence on yield.

There is a reported significant positive influence of both chemical and organic based fertilizers on the growth and performance of vegetables (Kale, Bano & Satyavati, 1991). The two key nutrient elements in limited supply are Nitrogen and Potassium, and their inadequacy in the soils can be well achieved through the applications of Nitrogen and Potassium based inorganic fertilizers (Maduagwuna, Asiegbu & Onyeonagu, 2021). The nutrient elements such as Sulphur (S), calcium (Ca), potassium (K), phosphorus (P), nitrogen (N) are essentially required for the cultivation of okra and maintenance of the fertility of the soil (Nyande, George, Kassoh & Bah, 2021).

The additional supplement of nutrients to the soils is integral in today's agriculture in order to achieve optimum performance and the complimentary application of different fertilizer types and formulations are largely known as one of the improved strategies for sustainable nutrition of the soil to (Majekodunmi *et al.*, 2021). It is on this note that this experiment was carried out to investigate the performance of Okra under the integrated application of NPK, Urea and Desert Lion foliar fertilizers. Though the application of Desert Lion foliar fertilizer can be affected by drifts due to wind, rainfall and application pressure, it has been used in cocoa production in Ghana over the years with significant performance on growth and yield. It is also less expensive compare with other chemical fertilizers on the market, and can be afforded by most vegetable growers in Ghana, who are predominantly resource-poor rural women. Hence, the need to

investigate its impacts on the growth and yield of other crops such as vegetables in a bid to get an effective and less expensive fertilizer type to help boost okra production.

MATERIALS AND METHODS

The study area

The trial was conducted on the field at CSIR-Crops Research Institute in, Kumasi. The study was carried out in 2019, during the major season which began in mid-March and extended to July and the minor season from September and ends in mid-November. The site is geographically located on latitude N 06°42.829 and longitude W 001°32.0032.

Soil analysis of the experimental field

Soil samples were taken from the experimental site at 20cm depth and the analysis for levels of pH, organic carbon, phosphorus, nitrogen, and exchangeable cations like Na, Mg, Ca, K,) was conducted at the laboratory of CSIR-Soil Research

Institute at Kwadaso, Kumasi. The glass pH-meter was used for the determination of pH at the soil to water ratio of 1:2.5 (Daniels, 2016). The Kjeldahl digestion and distillation procedure was employed to test for the organic carbon level (Daniels, 2016). The available phosphorus of the soil was also established by the Bray and Kurt protocol (Bray & Kurtz, 1945). The flame photometer method was used in testing for Sodium and Potassium, while the analysis for Magnesium and Calcium levels were performed by the Ethylene Diamine Tetra Acetic Acid titration method (Bray & Kurtz, 1945). The degree of acidity was examined by making a mixture of suspension of NaCl and soil of the ratio 100ml NaCl: 10g of soil in a plastic bottle of 250ml capacity, and shaken for an hour, allowed to settle, filtered and kept in Erlenmeyer flask. 50ml of the filtrate was taken in to a beaker with colour indicator, it was then titrated with NaOH till the pink colour was formed.

Table 1: Soil characteristics of the study area

Soil characteristics	Value (%)
pH	7.3
Available Phosphorus (%)	6.2
Percentage total Nitrogen (%)	0.1
Percentage organic Carbon (%)	0.9
Percentage organic matter (%)	1.6
Exchangeable Cations	Mean value (cmol (+)/kg)
K ⁺	0.4
Ca ²⁺	3.0
Mg ²⁺	0.7
Na ⁺	0.01
Texture	Mean value (%)
Sand	75.1
Silt	4.3
Clay	20.6
Soil texture	Sandy-clay-loam

Values are means of duplicate samples

Experimental design and field establishment

The experiment was laid out in the randomized complete block design (RCBD), with six treatments plus a control and replicated four times. The plot size was 5 m x 5 m, containing 5 rows. There were 2 m alleys between plots and 1.5 m between replications. The okra seed used was CRI-Kpando 001(genotype) sourced

from the Horticulture division of CSIR-Crops Research Institute, Kwadaso. Seed germination was hastened by pre-germination of soaking the seeds in water for about 8 hours. A planting distance of 70 x 40 cm was used, and seeds planted at 2 cm deep in the soil. Initially two seeds were planted per hill and was later thinned to one seedling per hill after germination.

Table 2: Treatment structure, rates and mode of application

Code	Treatment Structure	Rate and mode of application
T1	Control	No application of fertilizer
T2	NPK 15:15:15	50:30:30 kg ha ⁻¹ band placement @ 2 Weeks After Planting (WAP)
T3	Desert-Lion foliar fertilizer (DL)	25 ml/15 liters of water @ 2, 4, 6 and 8 WAP
T4	Urea (UREA)	50 kg ha ⁻¹ , band placement @ 4 and 6 WAP
T5	DL + P ₂ O ₅ and K ₂ O (DPK)	Basal application of 30 kg ha ⁻¹ each of P ₂ O ₅ and K ₂ O + 25 ml/15 liters of water of DL @ 2, 4, 6 and 8 WAP
T6	DL+ P ₂ O ₅ and K ₂ O + Urea (DPKU)	Basal application of 30 kg ha ⁻¹ each of P ₂ O ₅ and K ₂ O + 25 ml/15 liters of water of DL @ 2, 4, 6 and 8 WAP + 50 kg ha ⁻¹ of Urea @ 4 and 6 WAP

The Desert-Lion was applied using CP-15 knapsack sprayer.

Treatment application

The NPK at the rate of 50:30:30 kg ha⁻¹ was applied by band placement at 2 Weeks After Planting (WAP), the DL at 25 ml/15 liters of water was sprayed on the okra plants using knapsack sprayer at 2, 4, 6 and 8 WAP, urea at the rate of 50 kg ha⁻¹ was applied by band placement at 4 and 6 WAP. Also, the combination of basal application of 30 kg ha⁻¹ each of P₂O₅ and K₂O + spraying of DL at 25 ml/15 liters of water were done at 2, 4, 6 and 8 WAP. Combined basal application of 30 kg ha⁻¹ each of P₂O₅ and K₂O + spraying of DL at 25 ml/15 liters of water were carried out at 2, 4, 6 and 8 WAP + 50 kg ha⁻¹ of Urea at 4 and 6 WAP.

Data Collection

Data were taken on plant growth parameters: plant height (cm), number of leaves, number of branches and plant stem girth (cm). Data on yield parameters were also collected after harvesting of fruits, which are fruits per plant, length of fruit (cm), fruit girth (cm) and total fruit yield (kg ha⁻¹) at 8 to 14 WAP.

The Height of Plant (cm)

Plant heights of five randomly selected okra plants from each plot were measured in centimeters, using a meter rule. This was done by taking readings from the ground level up to the terminal point of the plant, and the means for each treatment were computed, at 2, 4, 6 and 8 WAP.

Number of Leaves

The leaves of the randomly selected five okra plants were counted at 2, 4, 6 and 8 WAP.

Number of Branches

Five okra plants were randomly selected and their branches were counted

and the means for each treatment were computed at 2, 4, 6 and 8 WAP.

Plant Girth (cm)

The girth diameter of the five randomly selected okra plants were measure at in centimeters 2, 4, 6 and 8 WAP using a pair of vernier calipers.

Fruits per Plant

The fruits of five plants were harvested from 8 to 14 WAP and the average for each treatment was calculated.

Length of Fruit

The lengths (in centimeters) of sample fruits were measured with a caliper and the means were calculated.

Fruit Girth

The girths of five fruits were determined in the middle portion with a pair of vernier calipers in centimeters and average girth for the various treatments taken.

Total Fruit Yield (kg ha⁻¹)

The fruits of all the 20 okra plants on the two middle rows were harvested, counted, and the weight recorded over the fruiting period in grams using an electronic scale and extrapolated to kilograms per hectare (kg ha⁻¹).

Data Analysis

Data analysis was performed using the fifteen edition of GenStat package. Count data (number of leaves, branches and fruits per plant) were subjected to square root Transformation, to cater for any zeros in order to follow the normal probability distribution before the analysis, and the means of treatments were separated by Least Significant Difference (LSD) at 5%.

RESULTS AND DISCUSSION

Plant Height

The influence of the treatments on the height of the okra plants was not

significant ($P > 0.05$) at the 2 WAP, however, at the 4, 6, 8 and 10 WAP the heights of the okra plants treated with the various treatments showed significant effect ($P < 0.05$). From 4 to 10 WAP, the okra plants treated with all the treatments with the exception of Desert Lion (DL) recorded significant increase in heights more than that of the control. The difference in heights of okra plants recorded from the control and DL treated okra plants were not significant ($P > 0.05$). The okra plants treated with NPK, UREA and DPKU had higher heights more than the rest of the treatments and the control at the 8 and 10 WAP. The DPK treated okra plants showed similar heights which were higher than that of DL treated okra plants and the control but less than NPK, UREA and DPKU treated okra plants at 10 WAP.

The application of the treatments demonstrated varying significant influences on the heights of okra plants at 4, 6, 8 and 10 WAP. The application of NPK, UREA, DPK and DPKU greatly enhanced the heights of the okra plants more than the DL and the control at 4, 6, 8 and 10 WAP (Figure 1). The effect of DL on the heights of okra plants was not significantly different from the control as they recorded heights of okra plants which were similar across the periods of the data collection. The application of NPK15:15:15 at 50:30:30 kg/ha, UREA at 50 kg/ha and DL at two weeks intervals after planting + basal application of P_2O_5 and K_2O + UREA at 50 kg ha^{-1} at 4 and 6 WAP (DPKU) demonstrated similar and higher influences on the heights of the okra plants than the other treatments and the control at 8 and 10 WAP (Figure 1).

The application of DL at the rate of 25 ml/15 liters of water at 2 weeks intervals up to 8 WAP + basal application of P_2O_5 and K_2O (DPK) on the okra plants showed similar heights which were higher than that of the application of sole DL at the rate of 25 ml/15 liters of water at two weeks intervals and the control but were less than the okra plants treated with NPK, UREA and DPKU at 10 WAP (Figure 1). The results showed that the application of DL alone has a very little influence on the height of okra as compare with the combined application of DL with P_2O_5 , K_2O and Urea. Analysis also showed that DL contains only about 8% of nitrogen and little amount of calcium and magnesium, and this may be the contributory factor for its poor performance on the heights of the okra plants when applied alone comparative to the application along with P_2O_5 , K_2O and the urea as well as the application of NPK, and DPK which all contain more than one basic plant nutrient. UREA is also known to have nitrogen levels more than that of DL and therefore might be the reason why it also performed higher than DL. Urea at 50 kg ha^{-1} influenced the plant height to about 111 cm, and it is in line with results of other authors which showed that 50 kg ha^{-1} of nitrogen increased the height of yellow pepper to 110 cm (Ekwu & Okporie, 2002). The results of the performances of the combined application of the foliar fertilizers + P_2O_5 and K_2O + urea is in line with that of (Ismail & Fayed, 2021) findings, which revealed that the combined application of P_2O_5 and K_2O + foliar application of some nutrients resulted to higher plant heights in okra plants than when there was no fertilizer application.

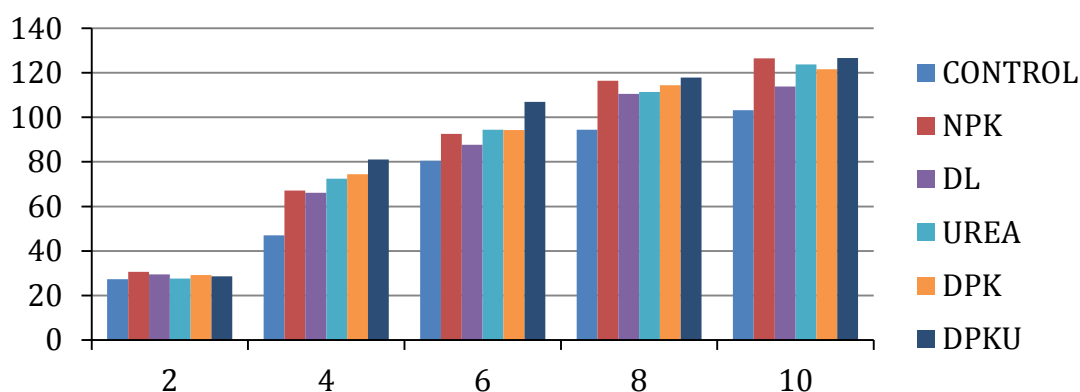


Figure 1: Effects of treatments on the height of okra plants. Error bars represent SEM.

Leaf per Plant

All the fertilizer treatments did not show significant differences ($P > 0.05$) on the number of leaves per plant at 2 WAP. DPKU and Urea treated okra plants recorded highest leaf per plant at 4 WAP, and the leaves per plant recorded by DPKU treated okra plants was higher than the rest of the treatments and the control (Table 3). The difference in the leaf per plant recorded among the treatments at 4, 6, 8 and 10 WAP was significant. DPKU treated okra plants yielded the highest leaf number per plant at 6, 8 and 10 WAP, which was more than the control, but not statistically different from that of the other treatments (Table 3). At the same period, the number of leaves produce per plant recorded among the okra plants treated with NPK, DL, UREA and DPK were similar.

The results of the number of leaves per plant recorded at the 2 WAP showed significant performances of the treatments ($P < 0.05$). however, the applications of the DL combined with the basal application of P_2O_5 and K_2O + Urea at 50 kg ha^{-1} at 4 and 6 WAP (DPKU) and the application of sole UREA at 50 kg/ha to okra plants influenced the production of higher leaf per plant of

approximately 15 and 14 respectively, which were more than the 11, 10 and 9 and 7 leaves per plant produced by the applications of NPK and DPK, DL and the control respectively at 4 WAP (Table 3).

The results reveal that application of DPKU to the okra plants exhibited significant positive performance in number of leaves per plant at 6, 8 and 10 WAP, which was more than the control, but was statistically not different from that of the okra plants which were treated with the NPK, DL, UREA and DPK (Table 3). It was also established from the data analysis that the DPKU demonstrated higher performance in leaves produced per plants from 4 to 10 WAP, which was significantly different from DL and control (Table 3).

The influence of DL on number of leaves produced per plant was actually lower (9 leaves per plant) against the performances of the other treatments which recorded 10 or above 10 number of leaves per plant. The content of DL has as low as 8% of nitrogen and little amount of other nutrients like calcium and magnesium, and this might therefore be the factor for the low influence when it was applied as a sole treatment compare

with higher performance when it was Urea at 4 and 6 WAP. applied with the basal P_2O_5 and K_2O and

Table 3: Effects of treatments on number of leaves per okra plant

Treatment	Leaf per plant				
	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
CONTROL	4.80	7.10	9.25	11.30	15.35
NPK	6.90	10.75	13.30	16.20	22.85
DL	6.15	9.10	11.25	13.55	15.40
UREA	7.35	14.55	17.90	18.00	25.35
DPK	5.55	10.50	15.15	21.05	20.70
DPKU	7.50	14.80	19.05	23.60	27.15
<i>P</i> -value	0.598	0.05	0.036	0.006	0.062
LSD (5%)	3.286	5.076	6.044	5.846	7.308
CV (%)	29.60	30.0	28.60	22.70	22.60

Branches per Plant

The data analysis showed difference influences of the treatments on number of branches produced per plant which were not significant ($P > 0.05$) at the 2 and 4 WAP. The number of branches recorded by a plant for all the treatments including the control was not different ($P > 0.05$) from one another at 2 and 4 WAP (Table 4). However, significant differences in number of branches per plant were recorded among the okra plants at 6, 8 and 10 WAP. At 6 and 8 WAP, the okra plants which were treated with DPKU produced the highest branches per plant and these differences were significantly higher than the control, but were not different from that of the remaining treatments (Table 4). At 10 WAP, DPKU treated okra plants gave more branches per plant and it was different and higher than the control, while the other treatments showed no difference in the branches obtained per plant at 8 WAP.

The number of branches per plant registered by all the treatments including the control showed no difference ($P > 0.05$) from one another at 2 and 4 WAP (Table 4). However, greater differences in the number of branches produced by a plant were recorded among the okra plants at 6, 8 and 10 WAP. At 6 and 8 WAP, okra plants which were treated with DPKU produced the highest branches and these were different from the control. And at 10 WAP, DPKU treated okra plants gave the highest number of branches per plant and it was different from the control, while the rest of the treatments showed no significant difference in number of branches per plant at 8 WAP. Similar research has reported significant influence on plant height, leaf bearing and branching in okra plants when different levels of some fertilizers composed of nitrogen and potassium were applied (Khan, Akand Md, Rahman Md, Islam Md & Ahmed, 2019).

Aggergy : Response of *Okra* to the Integrated of Fertilizers

Table 4: Effects of treatments on number of branches per okra plant

Treatment	Branch per plant				
	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
CONTROL	2.75	3.05	3.05	3.08	3.25
NPK	2.85	3.60	4.00	4.50	4.70
DL	2.35	3.15	3.30	3.50	3.55
UREA	2.90	4.50	3.75	4.85	5.25
DPK	2.65	3.50	3.65	3.80	4.25
DPKU	2.95	3.30	4.75	6.00	7.00
<i>P</i> -value	0.582	0.412	0.077	0.004	0.008
LSD (5%)	0.867	0.949	0.988	1.348	1.885
CV (%)	21.80	18.50	17.30	21.10	28.10

Plant Girth

The of statistical analysis of the girth of okra plants treated with the various treatments involved in this study revealed significant differences ($P < 0.05$) for the period of 2-10 WAP. The effect of Urea on plant girth was significantly different from the rest ($P < 0.05$) at 4 to 10 WAP (Table 5). However, significant effects ($P < 0.05$) on the girths of okra plants were recorded at 4 WAP, UREA treated okra plants had the highest plant girths against that of okra plants from the control. The

treatments demonstrated a significant difference ($P < 0.05$) in girths of okra plants at 4 to 10 WAP, the okra plants that were treated with UREA gave the highest plant girths against that of the control at 4 to 10 WAP (Table 5). Similar results have been reported that when some fertilizers containing nitrogen and potassium were applied to okra plants, they showed no different influence on the girth of the okra plants at 40 days after planting (Hemalatha, Selvi & Vasanthi, 2018).

Table 5: Effects of treatments on girth of okra plants

Treatment	Plant Girth (cm)				
	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
CONTROL	1.56	1.46	1.61	1.71	1.82
NPK	1.56	1.78	1.84	2.09	2.14
DL	1.46	1.52	1.63	1.76	1.82
UREA	1.62	1.82	1.88	2.13	2.27
DPK	1.55	1.56	1.67	1.91	2.13
DPKU	1.64	1.72	1.72	1.97	2.12
<i>P</i> -value	0.293	0.018	0.083	0.173	0.132
LSD (5%)	0.198	0.215	0.200	0.347	0.364
CV (%)	8.60	8.80	7.80	12.10	12.00

The number of Fruits per plant, Fruit Length, Fruit Girth

Significant influence ($P < 0.001$) was observed in fruits yield per an okra plant. The highest fruit count per plant was recorded by those okra plants treated with DPKU against the lowest registered by the control. But the variations in fruit count per plant recorded by NPK, DL, UREA, DPK and DPKU were not significant ($P > 0.05$) from one another (Table 6). The results of data analysis also indicated significant ($P < 0.05$) length and girth of okra fruits harvested during the experiment. The length of the okra fruits from the plants treated with DPKU was higher and different from the control (Table 6).

The fruit length of those okra plants treated with the UREA was also higher than the control but not different from the rest of the treatments. The girths of fruits harvested from the okra plants treated with DPKU and DPK were higher than the control. The girth of fruits obtained from DPKU treated okra plants was not different ($P > 0.05$) from that of the others, except DL and control (Table 6).

There were indications of influence of the application of the treatments in the number of okra fruits per plants. Again, the okra plants which were treated with the basal application of 30 kg ha^{-1} of P_2O_5 and 30 kg ha^{-1} of K_2O + foliar application of DL at 25 ml/15 liters of water + 50 kg ha^{-1} of urea at 4 and 6 WAP produced 40 okra fruits per plant, which was the highest against the 23 okra fruits per plant registered by the control which was the lowest. NPK, DL, UREA and DPK recorded 38, 35, 35, 37 and 39 okra fruits per plant

respectively, which were also higher than the control. Application of the treatments also demonstrated varying effects on the length and girth of okra fruits. The fruits from okra plants treated with P_2O_5 and K_2O at 30 kg ha^{-1} each + 25 ml/15 liters of water, DL + 50 kg ha^{-1} of urea at 4 and 6 WAP had highest length of 9.25 cm, which was significantly different from 4.63 cm of the control and 5.07 cm of okra fruits obtained from DL treated okra plants (Table 6). The length of fruits harvested from okra plants treated with UREA was 8.30 cm, significantly different from 4.63 cm of the control. The rest of the treatments, in terms of fruit length exhibited greater influence than UREA (Table 6).

The girths of fruits harvested from okra plants treated with DPKU and DPK were higher compare with the control. The girth of fruits obtained from DPKU treated okra plants was similar to the remaining treatments. The DL treated okra plants and the control performed lower than the other treatment in fruit girth (Table 6). It was generally observed that the soil application of Nitrogen, Phosphorus, Potassium together with foliar administration of the micronutrients (Ca and Mg) based DL significantly resulted in higher fruit count per plant, fruit length and girth of the okra plants as compare with the other treatments. This is line with another finding which revealed that the foliar spray of some micronutrients with soil application of macronutrients had significant influence on number of fruits per plant, length and girth of fruits of okra plants (Hemalatha , Selvi , & Vasanthi , 2018).

Table 6: Influence of the treatments on the number of fruits per plant, length and girth of okra fruits

Treatment	Fruit characteristics		
	No./Plant	Length (cm)	Girth (cm)
CONTROL	23.00	4.63	1.12
NPK	38.00	7.38	1.83
DL	35.00	5.07	1.24
UREA	37.00	8.30	1.70
DPK	39.00	7.97	1.88
DPKU	40.00	9.25	2.11
<i>P</i> -value	<.001	0.002	0.003
LSD (5%)	6.243	2.126	0.4619
CV (%)	12.00	19.90	18.60

Total fruit yield

The result of total fruit yield among the treatments revealed a significant difference ($P < 0.05$). The NPK, DPK and DPKU treated okra plants gave higher total fruit yield which were significantly different from the okra plants with other treatments and the control. The UREA treated okra plants also recorded total fruit yields which were higher than those treated with DL (Fig. 2).

The UREA and the DL treated okra plants also recorded the total fruit yields of about 6 t ha⁻¹ and 2.5 t ha⁻¹ respectively, and were higher than the total fruit yield of about 1 t ha⁻¹ of the control but were lower than that of 7.5 t ha⁻¹ of the NPK, DPK and DPKU (Figure 2). It was obvious that the foliar application of the micronutrients-based DL plus the application of the K, N and P arguably performed better on the growth and yield of okra plants. These results conform to earlier report which stated that foliar application of micronutrients with the soil application of N, P and K is the best nourishment for vegetables and cereals (Oosterhuis & Weir, 2010).

The treatments which formulations have more than one plant nutrient and combination of the fertilizers through foliar and soil (NPK, DPK and DPKU) performed higher than the treatments having single plant nutrient (sole UREA) and the sole foliar fertilizer (DL). The additions of the N, P and K to DL (treatments DPK and DPKU) contributed to the promising performances of these treatments in the height, leaves, branches and fruits per plant, and fruit yield, because N, P and K plays vital roles in plants. The P plays a critical function in energy transport, K in activation and mobility of essential enzymes for physiological and metabolic reactions and N in cell, genetics, nucleic acid and yield components. The number of branches per plant and fruits per plant contributed to yield directly, because, it was observed that the treatments NPK, DPK and DPKU which generally recorded good yield also had higher performances in the number of branches and fruits per plant.

Therefore, the absence of P, K and N in the DL and presence of only N in UREA could be the reasons for the low performances of these treatments against

the NPK, DKP and DPKU. Other authors have noted that absence or inadequacy of N, P and K can greatly hamper growth and

yield of crops (Hochmuth , Maynard , Vavrina , Hanlon , & Simonne , 2018).

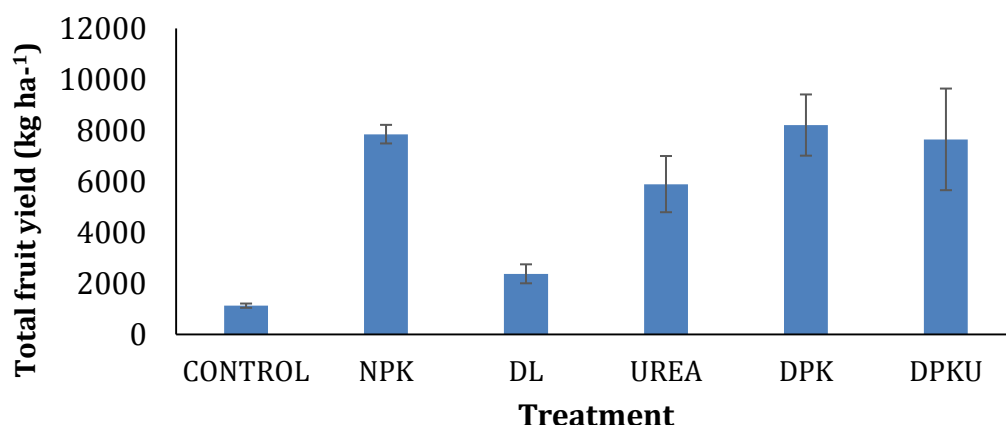


Figure 2: Effects of treatments on total fruit yield of okra. Error bars represent SEM

CONCLUSION

The applications of different types of fertilizers showed varied responses on the growth and yield parameters of okra. The combined application of Desert-Lion foliar fertilizer + P₂O₅ + K₂O + Urea, Desert-Lion foliar fertilizer + P₂O₅ + K₂O, and NPK demonstrated higher performances of 40, 39 and 38 okra fruits per plant and total fruit yields of 7.5 t ha⁻¹, 7 t ha⁻¹ and 7.5 t ha⁻¹ respectively, and these total fruit yields were about 80%, 70% and 78% higher than that of the total fruit yield of Desert-Lion foliar fertilizer. The sole urea application performed about 43% higher in the total fruit yield than sole Desert-Lion foliar fertilizer application, but was about 32% lower than that of integrated application of Desert-Lion foliar fertilizer + P₂O₅ + K₂O + Urea, combined application of Desert-Lion foliar fertilizer + P₂O₅ + K₂O, and NPK regarding number of fruits per plant and total fruit yield. The application of Desert-Lion foliar fertilizer alone did not give higher performance, but

when integrated with the urea and P₂O₅ + K₂O they exhibited promising performance on the growth and fruit yield of okra. Therefore, to achieve higher fruit yield in okra, the Desert-Lion foliar fertilizer should not be sprayed as a sole application, but it should be sprayed alongside basal P₂O₅, K₂O and urea.

Acknowledgment

The authors dully acknowledge the works and contributions of other authors, previous research and sources of other relevant information which contributed to the success of this work. We also appreciate everyone who formally and informally played a role in executing this research.

REFERENCES

- Daniels , W. L. (2016). The Nature and Properties of Soils, 15th Edition. *Soil Sci. Soc. Am. J.*, 80, 1428.
- Aderemi, A. Y., & Sangodoyin, A. M. (2019). Comparative Effects of Poultry Waste, Biochar and Blended

- Biochar on the Yield of Okra (*Abelmoschus esculentus*). *International Journal of Research and Scientific Innovation*, 6, 200-206.
- Bray , R. H., & Kurtz , L. T. (1945). Determination of total organic and available forms of phosphorus in soil. *Soil Science*, 59, 394-395.
- Devanda , P., Lakhawat , S. S., Pilania , S., Sharma , S. K., Mordia , A., Dudi , D. S., . . . Diwaker , P. (2021). Effect of Organic Manures and Liquid Formulations on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L. Moench) cv. *Arka Anamika International Journal of Current Microbiology and Applied Sciences*, 10(6), 2319-7706.
- Ekwu , L. G., & Okporie, E. O. (2002). Effect of Plant spacing and nitrogen fertilizer on the growth and yield of Pepper (*Capsicum annum* L.). *Agro-Science Journal of Tropical Agriculture, Food Environment and Extension*. 3(2), 22-26.
- Hemalatha , M., Selvi , D., & Vasanthi , D. (2018). Integrated Plant Nutrients Supply and Foliar Nutrition on Yield. *Madras Agriculture Journal*. 105(10-12), 517-523.
- Hochmuth , G., Maynard , D., Vavrina , C., Hanlon , E., & Simonne , E. (2018). *Plant Tissue Analysis and Interpretation for Vegetable* (Vol. HS964). Florida: IFAS Extension, University of Florida.
- Ismail , A. Y., & Fayed , A. M. (2021). Effect of Phosphorus Fertilization, Foliar Application with Seaweed Extracts and Micronutrients on Vegetative Growth and Dry Seed Yield of Okra (*Abelmoschus Esculentus* L.). *Menoufia J. Plant Prod*. 6, 423-440.
- Kale , R. N., Bano , K., & Satyavati , G. P. (1991). *Final report of KSCST project: N-67-04/Vermi. /34 B (3478)*.
- Khan , M. H., Akand Md. , H., Rahman, Md. , M., Islam Md. , M., & Ahmed , B. (2019). Effect of different levels of nitrogen and potassium on the growth and yield of okra. . *International Journal of Applied Research*, 5, 101-105.
- Maduagwuna , A. E., Asiegbu , J. E., & Onyeonagu , C. C. (2021). Response of Okra (*Abelmoschus esculentus* (L.) Moench) to N and K Fertilizer in an Ultisol. *Direct Research Journal of Agriculture and Food Science*, 9, 253-260.
- Majanbu, I. S., Ogunlela, V. B., Abmed, M. K., & Olarewaju, J. D. (1985). Response of two okra varieties to fertilizers, yield and yield components as influenced by nitrogen and phosphorus application. *Fertilizer Research*, 6(3), 257-267.
- Majekodunmi , O. A., Aderemi , A. M., Adedipe , J. O., Ogunwale , O. G., Oyewole , O. O., & Kuforiji , E. (2021). Effect of Poultry Manure and NPK 15:15:15 Fertilizer on the Growth, Development and Yield of Okra (*Abelmoschus esculentus* L.). *Global Scientific Journals*, 9, 9(7), 1974-1979.
- Nyande , A., George , M. S., Kassoh , F. A., & Bah , A. M. (2021). Growth and yield response of okra (*Ablemochus esculentus*) to varying rates of different sources of organic soil amendments at Njala, Moyamba District, Southern Sierra Leone. *African Journal of Agricultural Research*, 17(8), 1144-1154.
- Oosterhuis, D. M., & Weir , B. L. (2010). Foliar fertilization of cotton. In J. M. Stewart, *Physiology of Cotton* (pp. 272-288). Springer Science + Business Media B.V.