academicJournals

Vol. 12(24), pp. 2056-2062, 15 June, 2017
DOI: 10.5897/AJAR2017.12438
Article Number: E4B4F7164729
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Effects of different soil amendments on the performance of okra (*Abelmoschus esculentus* L.) in a bimodal rainforest zone

KWAYEP Lambert Natan[1], SUH Christopher[2*], KONJE Christina[1], MANGA Ambroise[2], KENFO Thomas[1], LOMBEKO Victorine[2] and DJOMO SIME Hervé[2]

[1]College of Technology, University of Bamenda, P.O. Box 39 Bambili, Cameroon.
[2]Institute of Agricultural Research for Development (IRAD), P.O. Box 2123, Yaoundé, Cameroon.

Received 9 May, 2017; Accepted 25 May, 2017

Okra contributes an important part of the diet to many people in the tropics, more especially in Cameroon. But its production is seriously affected by poor soil fertility. In other to mitigate this problem, a field experiment was conducted from April to august 2016 at Institute of Agricultural Research for Development (IRAD) Nkolbisson-Yaoundé with the main objective to evaluate the effects of different soil amendments on the performance of okra (*Abelmoschus esculentus* L.) crop. The experiment was laid out using a randomized complete block design (RCBD) with three replications and eleven treatments: (Tithonia leaves (6700 kg/ha), piggery manure (6700 kg/ha), foliar fertilizer (0.6 kg/ha), urea (200 kg/ha), NPK20-10-10 (200 kg/ha), Tithonia leaves (3350 kg/unit) + NPK20-10-10 (100 kg/unit), Tithonia leaves (3350 kg/unit) + Urea (100 kg/ha), urea (100 kg/ha) + NPK 20-10-10(100 kg/ha), Tithonia leaves (100kg/ha) + foliar fertilizer (0.3 L/ha), Tithonia leaves (3350 kg/ha) + piggery manure (3350 kg/ha) and control (0 kg/ha). The Results showed that the growth and yield of okra were significantly (P<0.05) affected by different soil amendments. The number of days to achieve 50% shoot set was significantly (P<0.05) greater (50.66±1.24) with the use of NPK 20-10-10 as compared to the rest of the treatments. The number of days to achieve 50% flowering was significantly (P<0.05) greater (59.33±1.46) with the use of Tithonia leaves as compared to the rest of the treatments. The tallest plants and highest number of fruits per plant were recorded from the urea treatment, while the use of foliar fertilizer resulted in many branches and leaves per plant. A combination of NPK and Tithonia leaves resulted in heavy fruits per plant. NPK treatments produced the highest number of fruits and the heaviest fruits as compared to the foliar and control treatments. From the results obtained, it can be concluded that the application of foliar fertilizer, urea and NPK 20-10-10 + Tithonia and NPK which recorded the highest growth and yield parameters among all the treatments are the best treatments and should be adopted by farmers in the study area to maximize their yields. However, further studies on other combinations of organic fertilizers need to be carried out in different areas in order to come out with desired new alternatives that will reduce the use of high quantity of inorganic fertilizers.

Key words: Performance, soil amendments, okra, bimodal, fertilizer.

INTRODUCTION

The importance of vegetables in providing balanced diet and nutritional security has been realised world over

(Adeniji and Peter, 2005). Vegetables are now recognized as healthy food globally and play important role in overcoming micronutrient deficiencies and providing opportunities of higher farm Income. Okra *(Abelmoschus esculentus* L.) Moench) originated from tropical Africa and India (Alkaff and Hassan, 2003), it is one of the most well-known and utilized species of the family Malvaceae in Cameroon. It is also an important vegetable crop grown for its immature pods that can be consumed as a fried or boiled vegetable or may be added to salads, soups and stews (Adeniji and Peter, 2005). Mature okra seeds are good sources of protein that could be as high as poultry eggs and soybean (Akintoye et al., 2011). In Cameroon, okra occupies the third place after tomato and pepper (AGRISTAT, 2014) in terms of vegetable production. Although okra is very popular in Cameroon, the yield is still low (3.11 tons /ha) due to biotic and abiotic factors (FAOSTAT, 2013). The low yield has been attributed to poor soil fertility and deficiency in important mineral nutrients (Sanchez and Jama, 2002). This is because fertilizers have become a scarce commodity and even when available; it is beyond the reach of the poor resource farmers due to high costs (Farinde and Owalarefe, 2007). Both fertilizers and organic manures have a potential role in crop growth and development (Eghball et al., 2004). Organic manures improve soil fertility by activating soil microbial biomass (Ahmad et al., 1998). Animal and plant manure provide a source of all necessary macro- and micro nutrients in available forms, thereby improving the physical and biological properties of the soil (Abou El Magd et al., 2006). According to Olatunji et al. (2007), the application of organic manure had been found to have higher comparative economic advantage over the use of inorganic fertilizer. Common organic materials such as animal manure are not usually available in sufficient quantities and their application is labour intensive (Palm et al., 1997). Therefore, there is need to use alternative sources of organic fertilizers such as green manure to enrich the soil for crop production. According to Chukwuka and Omotayo (2008) and Crespo et al. (2011), *Tithonia diversifolia* can improve the physical and chemical properties of soil and increase nutrients in the soil. Igua and Huasi (2009) also reported that residues of *T. diversifolia* increases soil nitrogen and consequently increases maize yield. Piggery manure contains nitrogenous compounds (including ammonia, ammonium compounds and nitrates) (Bertora et al., 2008). It also contains phosphoric compounds, which mainly occur in inorganic form (74 to 87% of the total P content) (Lens et al., 2004). This composition therefore makes piggery manure useful in agriculture (Fangueiro et al., 2012). The purpose of this study was to evaluate the effect of *T. diversifolia* green manure and piggery manure in improving the physical and chemical properties of soils as well as yield of okra.

With limited information on response of okra to application of piggerygery manure and Tithonia in fatalistic soils of Yaoundé, the study was carried out with the main objective of evaluating the effects of these organic matters on the production of okra with inorganic fertilizer.

MATERIALS AND METHODS

The study was conducted at Institute of Agricultural Research for Development (IRAD) Nkolbisson –Yaoundé- Cameroon in the month of April to August 2016. The study site (Figure 1) is located at an altitude of 759 m above sea level and lies at latitude 3° 51'N and longitude 11° 40'E. The annual rainfall distribution is bimodal with peak rainfall in May and October. The area has a mean annual rainfall of 1500 mm and mean annual temperatures of 24.7°C .The relative humidity range between 50 and 80% in the dry season and 70 and 90% in the rainy season. The most dominant types of soil at Nkolbisson is ferralitic, and acidic (pH 5- 6) with a low cation exchange capacity (CEC). A cultivar (Clemson Spineless) of okra was used as the planting material. This variety was obtained from AVRDC (world vegetable centre).

The treatments consisted of Tithonia (6700 kg/ha), piggery manure (6700 kg/ha), foliar fertilizer (70% N, 25% P, 5% K, trace elements, vitamins and amino acids) (0.6L/HA), urea (200 kg/ha), NPK20-10-10 (100 kg/ha), Tithonia (3350 kg/ha) + NPK20-10-10 (100 kg/ha), Tithonia (3350 kg/ha) + urea (100 kg/ha), urea (100 kg/ha) + NPK20-10-10 (100 kg/ha), Tithonia (100 kg/ha) + foliar fertilizer (0.3 L/HA), Tithonia (3350 kg/ha) + piggery manure (3350 kg/ha) and control (0 kg/ha). The experiment was laid out in a randomized complete block design (RCBD) with 11 treatments replicated three times. Blocks were separated from each other by a 1 m path. Each plot measured 4 x 1.5 m, giving a surface area of 6 m^2 and okra was sown 40 cm between rows and 30 cm within rows with 52 plants per plot.

The soil was treated with Chloropyrifos which is an organophosphate insecticide in order to reduce the insect population. Piggery manure and Tithonia were mixed with the soil on their respective seedbed two weeks before planting so as to enable the decomposition and the release of nutrients before planting. Leaves of *T. diversifolia* were harvested, slashed into smaller sizes before incorporating into the soil, while npk and urea fertilizers were applied two weeks after sowing. Foliar fertilizer at 0.6 L/ha was applied weekly 14 days after sowing (DAS). 4 grains of Clemson Spineless okra variety were sown per hole at a depth of about 1 cm deep at a spacing of 40 cm between line and 30 cm between stand. This was later thinned to 2 plants per stand. The thinning operation was done two weeks after emergence when 2-3 true leaves were produced giving a total of 52 plants per plot. The trial was kept relatively weed free almost every week till harvest. Cypermethrin (250 ml/Ha) and chloropyrifos (340 ml/ha) were used to control diverse insects, while the fungicides Mancozeb & Imidachlopride at the rates of 5L/Ha were used to prevent fungal attack.

Data on growth parameters were taken. Plant height was

Corresponding author email: suhchristopher@yahoo.com.

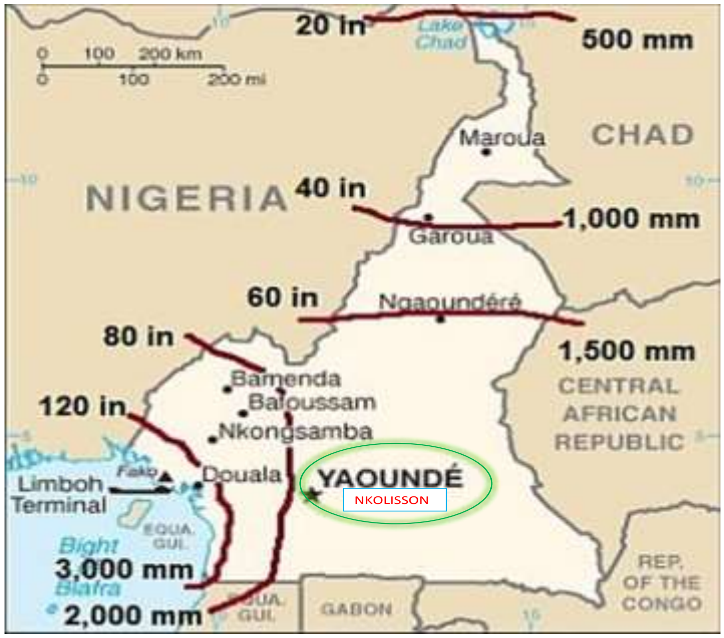

Figure 1. Map of the study area.

Table 1. Effects of different soil amendments on the growth and development of okra.

Treats	Plant height/plant 30 DAS	plant height/plant 60 DAS	Leaf number/plant 30 DAS	Leaf number/plant 60 DAS	Number of branches/plant 30 DAS	Number of branches/plant 60 DAS
CON	12.36±2.54^{bc}	43.78±7.58^{fg}	3.83±0.32^{abc}	11.11± 3.22^{d}	2.56±1.65 ^{ab}	3.06 ±1.29^{ab}
FLR	11.42±2.33^{c}	43.00±8.06^{g}	3.50± 0.47^{d}	15.77±5.01 ^{a}	2.89±1.71^{a}	3.28±1.47^{a}
FLR +THN	14.86±2.75^{a}	49.44±6.85^{efg}	3.88±0.28 ^{ab}	11.78±1.58 ^{cd}	0.67±1.53^{e}	1.72±1.05^{d}
NPK	14.75±1.69^{a}	63.28±9.57^{bc}	4.00±0.09^{a}	13.00±2.39^{bcd}	1.11 ±1.07^{cde}	2.39 ±1.06^{bcd}
NPK+THN	14.14±2.17^{a}	55.00±6.28^{de}	3.88±0.49 ^{ab}	11.11±2.62^{d}	1.89 ±1.84^{abcd}	2.39 ±1.17^{bcd}
NPK+URA	13.75±2.20^{ab}	50.89±8.54^{e}	3.61±0.41 ^{cd}	11.61±1.99^{cd}	1.11±1.65^{cde}	2.33±1.05^{bcd}
PGM	11.88±2.70^{c}	49.72±9.79^{ef}	3.72 ±0.50^{bcd}	13.17±3.43^{bcd}	2.56±1.68^{ab}	2.94±1.41^{ab}
PGM+THN	13.86±3.01^{ab}	60.22±8.09^{cd}	3.94±0.40 ^{ab}	14.94±3.88^{ab}	0.72±1.32^{e}	1.67±1.07^{d}
THN	11.91±2.39^{c}	53.89±14.07^{de}	3.72±0.40 ^{bcd}	12.39±1.82^{cd}	2.11 ±1.20^{abc}	2.61±1.17^{abc}
URA	14.25±2.59^{a}	73.33±13.86^{a}	3.94 ±0.27^{ab}	13.28±3.78^{bc}	1.61 ±1.57^{bcde}	2.11±1.48^{cd}
URA+THN	14.08±2.94^{a}	67.22±13.97^{ab}	3.94 ±0.27^{ab}	13.06 ±3.64^{bcd}	0.89 ±1.74^{de}	2.06±1.45^{cd}

Means followed by the same letter(s) on same column are not significantly different at 5% level of significance. NPK (Nitrogen, phosphorous and potassium), CON (Control), FLR (foliar fertilizer), PGM (piggery manure), THN (Tithonia leaves), URA (urea).

measured from soil level to the tip of the highest leaf with a meter rule. Number of leaves was counted at 30 and 60 days after sowing (DAS), and the number of days to achieve 50% flowering and 50% pod set were recorded. The number of fresh pods per plant (yields) and the average fresh pod weight were recorded. The data were subjected to analysis of variance (ANOVA using JMP software).

RESULTS AND DISCUSION

The results indicated that the different soil amendments had highly significant ($P < 0.05$) effect on plant height (Table 1). At 30 DAS, the tallest plants (14.86 cm) were recorded from the combined treatment of foliar fertilizer and Tithonia which was significantly ($p < 0.05$) taller than those of control, piggery manure and Tithonia applied alone. At 60 DAS, the tallest plant (73.33 cm) was recorded from the urea treatment while the shortest plant (11.42 cm) came from the foliar fertilizer treatment. Urea gave the best performance with regards to okra height with the reason being a better nitrogen release than the

Table 2. Effects of different soil amendments on the number of days to achieve 50% shoot set and 50% flowering by okra.

Treatments	Days to 50% shoot set	Days to 50% flowering
CON	39.00±2.27^{d}	46.33±2.38^{d}
FLR	48.67±0.32^{ab}	46.33±2.38^{d}
FLR+THN	48.00±1.40^{ab}	56.33 ±0.65^{ab}
NPK	50.67±1.24^{a}	58.00±0.65^{a}
NPK+ THN	47.33±0.94^{ab}	54.67±0.90^{ab}
PGM	41.33±2.10^{cd}	49.00±2.55^{cd}
PGM+ THN	45.00 ±6.43^{bc}	52.33 ±7.50^{bc}
THN	50.00±3.48^{a}	59.33±1.46^{a}
URA	49.00±1.80^{ab}	57.33± 1.46^{ab}
URA+NPK	50.00±1.23^{a}	58.67±0.90^{a}
URA+ THN	50.33±1.12^{a}	59.00±1.50^{a}

Means followed by the same letter(s) on same column are not significantly different at 5% level of significance. NPK (Nitrogen, phosphorous and potassium), CON (Control), FLR (foliar fertilizer), PGM (piggery manure), THN (Tithonia leaves), URA (urea).

other treatments. Results are also in line with the findings of Bin-ishaq (2009) who reported that urea is associated with significant progressive increases in height of okra plant. The increase in plant height at 60 days after sowing probably is due to the supply of more nutrients from inorganic fertilizer at the critical growth stage (flowering and fruit set) which corroborates the findings of Naik et al. (2002) who reported that urea subsequently increases plant height of okra over NPK, poultry, urea and Tithonia.

The number of leaves per plant at 30 DAS was significantly (P<0.05) increased by the application of NPK 20-10-10, urea + Tithonia leaves, piggery manure + Tithonia leaves, urea, foliar fertilizer + tithonia leaves and NPK 20-10-10+Tithonia leaves. With the highest number of leaves (4) recorded on NPK and the lowest number (3.5) of leaves on foliar fertilizer. At 60 DAS, the number of leaves from foliar fertilizer treatment was significantly (p<0.05) different from other treatments. Foliar fertilizer treatment recorded the highest number of leaves (15.77), while the treatment NPK 20-10-10 plus Tithonia and the control had the lowest number of leaves (11.11).

Generally, number of branches per plant is an important indicator of the yield component. The result of the study revealed that the different soil amendment had significant (P < 0.05) effects on the number of branches of the okra plant (Table 1).

During the first 30 days after sowing, the treatment with foliar fertilizer had the highest number of branches (2.99) as compared to others. The number of branches from control, Tithonia, piggery manure and foliar fertilizer treatments were not significantly (P >0.05) different. The number of branches was significantly different in the control treatment than other treatments, except foliar fertilizer (2.56). The lowest number of branches was recorded from foliar fertilizer plus Tithonia treatment (0.67). At 60 days after sowing, number of branches (3.29) on foliar fertilizer was significantly (p<0.05) higher as compared to others. The lowest number of branches was also recorded on foliar fertilizer plus Tithonia leaves application (1.72). Foliar fertilization does not only improve plant growth traits, crop yields and nutrient uptake but also enhances nutrient use efficiency. The results below showed that the highest number of branches was found on plots treated with foliar fertilizer. These benefits of the foliar fertilizer under study might be related to its multi-nutrient content, which upon absorption by the leaf tissues improved the growth traits of okra plants and resultantly increased okra branches. This notion is further supported by the findings of Chaurasia et al. (2005) who also reported that enhanced growth traits, increased yield and better nutrient uptake by vegetable crop was influenced by foliar fertilization. This is contrary to the findings of Abbas et al. (2010*)* who reported that the soil or leaf application of recommended chemical fertilizer alone remained more effective in producing more branches of okra than the single application of three foliar fertilizer products.

Effects of different soil amendments on the yield components

Results from Table 2 indicated a significant difference (p < 0.05) in number of days to achieve 50% flowering and shoot set by the okra variety from the various treatments. According to the results, NPK 20-10-10, Urea+Tithonia, Tithonia and Urea+NPK 20-10-10, showed highly significant (p < 0.05) difference in the number of days to achieve 50% shoot set and flowering as compared to the other treatments. However, NPK 20-10-10 took the highest number of days (50.67) to achieve 50% shoot set, while Tithonia took 59.33 days to achieve 50% flowering. The application of NPK 20-10-10,

Table 3. Effect of different soil amendments on the yield components of okra.

Treatments	Number of fruits / plant	Weight of fruits(g)/plant	Number of fruits(g)/treatment	Weight of fruits(g)/treatment	Weight of grains(g)/treatment
CON	5.89 ±2.04^{c}	26.66±14.93^{bc}	191.00^{ab}	2900.00^{b}	285.67^{ab}
FLR	8.28±3.04^{ab}	33.56±14.45^{ab}	147.00^{b}	2900.00b	293.53^{ab}
FLR + THN	6.22±1.42^{c}	29.22 ±6.37^{ab}	202.00^{ab}	1466.67ab	330.08^{ab}
NPK 20-10-10	9.28±2.99^{a}	35.78±14.08^{a}	305.33^{a}	5200.00a	521.52^{a}
NPK 20-10-10+ THN	8.17±2.19^{ab}	36.57±13.96^{a}	199.67^{ab}	3833.33ab	378.50^{ab}
NPK 20-10-10+URA	6.94±2.19^{bc}	28.25±9.89^{ab}	157.00^{b}	3033.67b	203.50^{b}
PGM	8.39±2.78^{ab}	21.18 ±13.02^{c}	158.66^{b}	2533.33^{b}	286.75^{ab}
PGM+ THN	9.28±3.12^{a}	33.66±7.04^{ab}	245.00^{ab}	3866.67^{ab}	484.18^{ab}
THN	7.22±2.64^{bc}	30.73±7.86^{ab}	234.00^{ab}	3366.67^{ab}	445.61^{ab}
URA	9.83±2.78^{a}	34.09±11.68^{ab}	237.00^{ab}	3900.00^{ab}	392.91^{ab}
URA+THN	5.83±2.63^{c}	33.59±6.63^{ab}	234.00^{ab}	4200.00^{ab}	396.95^{ab}

Means followed by the same letter(s) on same column are not significantly different at 5% level of significance. NPK (Nitrogen, phosphorous and potassium), CON (Control), FLR (foliar fertilizer), PGM (piggery manure), THN (Tithonia leaves), URA (urea).

Urea+Tithonia leaves, Tithonia leaves and Urea+NPK 20-10-10, extended the period to achieve 50% shoot set as compared to the control (39.00) and piggery manure (41.33) which recorded shorter periods. The results also showed no significant differences between urea, foliar fertilizer, foliar fertilizer+tithonia and NPK 20-10-10+Tithonia. This result is in contrast to the findings of Ekwu and Nwokwu (2012) who reported that high amounts of nitrogen on okra reduced the flowering period. Kawthar et al. (2010) reported that reduction in number of days to 50% flowering observable with fertilizer treated plants could be attributed to acceleration of the vegetative phase through the stimulating effect of the absorbed nutrients during photosynthetic process which reflected on both vegetative growth and flower initiation.

Urea had the highest number of fruits (9.83) significantly different from Urea+Tithonia (5.89) and control treatments (5.83) that had the lowest number of fruits/plant. It is also worthnoting that all the treatments had a higher number of fruits/plant as compared to the control. The results indicated that urea has a significant influence on the fruit height of okra. This capacity of producing more fruit is probably due to high nitrogen content of urea which could favour the photosynthetic activity of the plant. This result corroborates that of Akande et al. (2003) who reported that urea increases productivity and improves yield. Contrary, Awodun (2007) observed that more fruits are produced in response to applying foliar fertilizer than urea.

Regarding fruit weight, NPK 20-10-10+Tithonia produced the heaviest fruits per plant (36.57 g) as compared to other treatments, while the lightest fresh okra fruit weight was recorded from piggery manure (21.66 g). The result also showed that there was no significant difference ($p<0.05$) between NPK 20-10-10 + Tithonia (36.57g) and Tithonia alone (36.57) treatments in terms of fruit weight. The fruit weight/plant was not significantly different between control, NPK 20-10-10+Urea and piggery manure, but was significantly different ($p<0.05$) as compared to the treatments: Tithonia alone, urea, foliar fertilizer, urea+Tithonia, foliar fertilizer+Tithonia, and piggery manure +Tithonia.

The main effect of NPK 20-10-10+Tithonia application showed significant increase on fresh fruit weight per plant as shown in Table 3. The heaviest fresh fruit weight per plant from NPK 20-10-10+Tithonia treatment can be related to nutrient availability to crops and release patterns by NPK 20-10-10+Tithonia. This result indicates that combination of NPK 20-10-10 and Tithonia as soil treatment is a better nutrient package for okra. This may be due to the fact that the inorganic fertilizer component of the mixture provided early nutrients to the growing crop, while the organic component provided additional nutrients at the later stage of the crop's development. This finding corroborates with the view of Chung et al. (2000), who reported that the application of organic manures fortified with adequate amount of inorganic fertilizer positively influenced crop yield. This finding also confirmed the results of Ayoola and Makinde (2007) who reported that organic fertilizer can be enriched with inorganic fertilizer to obtain optimum crop yield. This ability of NPK to produce heaviest fruits shows that NPK was readily available and in the best form for easy absorption by the plant root. The obtained results corroborated the finding of Tiamiyu et al. (2012) where they reported that, inorganic fertilizer could increase fruit weight of crops when compared with other sources of manures.

Weight of grains (g)/treatment

The weight of grains per treatment showed that NPK treatment had highly significant effect on the weight of grains per treatment. This analysis showed that NPK had the heaviest grains weight (521.52 g) per treatment as compared to others. The lightest grains were recorded on NPK+urea treatment (203.50). These results also showed that there were no significant ($p>0.05$) different between all the treatments, except NPK+urea.

This ability of inorganic fertilizer to produce heavier grains might be due to the fact that NPK has the capacity to produce more nutrients as well as high photosynthetic activity. The increase in the yield might be due to greater availability of nutrients in which their presence plays a significant role in food storage and seed maturity. This is in conformity with Guievence and Budence (2000) who reported increased uptake of nutrients, resulting in more photosynthesis and enhanced food accumulation in edible part of the fruits as well as seeds maturity.

Conclusion

Although, okra can be cultivated without the application of fertilizers as seen in the control treatment, this study shows that the growth and yield of okra is greatly enhanced by the application of organic and inorganic fertilizers.

It was also observed from the study that urea produced the tallest plants, while the foliar fertilizer gave the highest number of leaves and branches at 60 days after sowing. For yield components, urea and NPK 20-10-10+Tithonia treatments gave the highest number of fruits/plant and the highest mean fruit weight, respectively. The highest number of fruits and the fruit weight per treatment were recorded on NPK fertilizer. The results also revealed that organomineral (organic + inorganic) fertilizers maintained the highest number of plant stands as compared to sole applications. And application of urea, foliar fertilizer and NPK 20-10-10+ Tithonia proved to be efficient as a good source of fertilizers that supported good vegetative growth and fruit yield in okra. A combination of tithonia or piggery manure and inorganic fertilizer greatly boost the production of okra in terms of fruit weight and number and this is economical for peasant farmers lacking means to obtain inorganic fertilizers.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

REFERENCES

Abbas MA, Baloch, Zia-ul-hassan, Wagan KH, Shah AN (2010). Growth and yield of okra under foliar application of some new multinutrient fertilizer products. pakistan. J. Agric. Eng. Vet. Sci. 26(2):11-18.

Abou El-Magd MM, El-Bassiony AM, Fawzy ZF (2006). Effect of organic manure with or without chemical fertilizers on growth, yield and quality of some varieties of Broccoli plants. J. Appl. Sci. Res. 2(10):791-798.

Adeniji OT, Peter JM (2005). Stepwise regression analysis of pod and seed yield characters in segregating F2 population of West African okra (Abelmoschus caillei). Proceedings of 30th Conference, Genetics Society of Nigeria 8(1):250-258.

AGRISTAT (2014). Statistical Yearbook of the Agricultural Sector in Cameroon. Ministere De l'Agriculture et du Developpement Rural, Yaounde, Cameroon (In French).

Ahmad S, Naz SY, Raja MR (1998). Effect of farmyard manure, crop residues and mineral fertilizers on wheat yield under rain-fed conditions. Pak. J. Soil Sci. 14(1-2):111-113.

Akande MO, Oluwatoyinbo FI, Adediran JA, Buari K, Yusuf IO (2003). Soil amendments affect the release of P from rock phosphate and the development and yield of okra. J. Veg. Crop Prod. 9(1):3-9.

Akintoye HA, Adebayo AG, Aina OO (2011). Growth and yield response of okra intercropped with live mulches. Asian J. Agric. Res. 5:146-153.

Alkaff HA, Hassan AA, (2003). Effect of biofertilizer, organic fertilizer and foliar application of power 4 on the growth and yield of okra plants. J. Nat. Appl. Sci. 7(2):25-35.

Awodun MA (2007). Effect of Goat Manure and Urea Fertilizer on Soil, Growth and Yield of Okra (*Abelmoschus esculentus* (L.) Moench). Int. J. Agric. Res. 2:632-636.

Ayoola OT, Makinde EA (2007). Fertilizer Treatment Effects on okra.and Determination of total organic P and available forms of phosphorus in soils. Soil Sci. 59:39-45.

Bertora C, Alluvione F, Zavattaro L, van Groenigen JW, Velthof G, Grignani C (2008). Pig slurry treatment modifies slurry composition, N_2O, and CO_2 emissions after soil incorporation. Soil Biol. Biochem. 40:1999-2006.

Bin-Ishaq MS (2009). Effect of plant density and nitrogen fertilization on vegetative growth, seed yield and quality of okra plants. Appl. Nat. Sci. Foundation 16(4):45-55.

Chaurasia SNS, Singh KP, Rai M (2005). Effect of foliar application of water soluble fertilizers on growth, yield, and quality of tomato (*lycopersicon esculentum* l.) sri Lankan J. Agric. Sci. 42:66-70.

Chukwuka KS, Omotayo EO (2008). Effects of *Tithonia* green manure and water hyacinth compost application on nutrient depleted soil in South-Western Nigeria. Int. J. Soil Sci. 3(2):69-74.

Chung RS, Wang CH, Wang CW, Wang YP (2000). Influence of organic matter and inorganic fertilizer on the growth and Nitrogen accumulation of Crop plants. J. Plant Nutr. 23:297-311.

Crespo G, Ruiz TE, Álvarez J (2011). Effect of green manure from Tithonia (*T. diversifolia*) on the establishment and production of forage of P*. purpureum* cv. Cuba CT-169 and on some soil properties. Cuban J. Agric. Sci. 45(1):79-82.

Eghball B, Ginting D, Gilley JE (2004). Residual effects of manure and compost applications on corn production and soil properties. Agron. J. 96:442-447.

Ekwu LG, Nwokwu GN (2012). Effect of plant spacing and planting date on the growth and yield of okra. Int. J. Agric. Rural Dev. 15(2):1041-1048.

Fangueiro D, Lopes C, Surgy S, Vasconcelos E (2012). Effect of the pig slurry separation techniques on the characteristics and potential availability of N to plants in the resulting liquid and solid fractions. Biosyst. Eng. 113:187-194

FAOSTAT (2013). Statistical database: Food and Agricultural Organisation (FAO) Italy: Rome; 2013.

Farinde AO, Owalarefe LB (2007). Nigeria Fertilizer Sector, Present Situation and Future Prospects IFDC.Fertilizer Research 29: 35-44. First International Symposium on Taxonomy of Cultivated Plants: ActaHorticulture 182:133-144.

Guievence I, Badem H (2000). Effect of foliar application of different sources and levels of nitrogen on growth and yield of tomato (*Lycopersicon esculentum* L.). Indian J. Agric. Sci. 72(2):104-105.

Igua P, Huasi L (2009). Effect of chicken manure, *Tithonia diversifolia* and *Albizza* spp. on maize plant height and dry matter production-Lessons learnt in the Eastern highlands of Papua New Guinea. *Peer Review Paper at the 17th International Farm Management Congress*. July 2009. Bloomington/Normal, Illinois, USA pp. 240-251.

Kawthar AE, Rabie H, Manaf-Hasnaa HH, Gouda AH, Shahat IM

(2010). Influence of Compost and Rock Amendments on Growth and Active Ingredients of Safflower Carthamus tinctorius L.). Austr. J. Basic Appl. Sci. 4(7):1626-1631.
Lens PB, Hamelers H, Hoitink W, Bidlingmaier W, (2004). Resource Recovery and Reuse in Organic Solid Waste Management .IWA Publishing pp. 249-261.
Naik LB, Prabhakar M, Tiwari RB, (2002). Influence of foliar sprays with water soluble fertilizers on yield and quality of Carrot (Daucus carota L). International Conference of Vegetables, Bangalore P 183.
Olatunji CA, Ighodo U, Igiri JN (2007). Soil survey report of the Niger Delta. Federal Government Action of the Niger Delta P. 158.
Palm CA, Myers RJK, Nandwa SM, (1997).Combined use of organic and inorganic nutrient sources for soil fertility maintenance and replenishment. In: R.J. Buresh *et al.* (eds). Replenishing Soil Fertility in Africa. SSA Special Publ. 51. SSA. Madison. USA pp. 193-217.
Sanchez PA, Jama BA (2002). Soil fertility replenishment takes off in East and Southern Africa. in: Vanlauwe, B., J. Diels, N. Sanginga and R. Merckx (eds) Integrated Plant Nutrient Management in Sub-Saharan Africa. CAB International, Wallingford, UK. pp. 23-45.
Tiamiyu RA, Ahmed HG, Muhammad AS (2012). Effect of sources of organic manure on growth and yield of okra (*Abelmoschus esculentus (*L.) Moench) in Sokoto, Nigeria. Nigerian J. Basic Appl. Sci. 20(3):213-216.