Effect of Selected Organic Residues and Inorganic Fertilizers on the Performance of Okra (*Abelmoschus esculentus*)

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Abstract. In a bid to evaluate the effect of selected organic residues and inorganic on the performance of okra (*Abelmoschus esculentus*), a concurrent experiment was conducted using *Gliricidia sepium* and *Aspilia africana* as the source of organic residue while N:P:K and urea were used as the sources of inorganic fertilizers. The materials were applied solely and in combinations to give a total of nine treatments. The land area used was 28m by 11m partition into 9 plots and replicated three times to give a total of 27 experimental units. The experiment was laid out in a randomized Complete Block Design. Okra variety lady finger was planted at a spacing of 60cm by 45cm at a rate of three seeds per hole which was later thinned to one plant per stand. The treatments were applied two weeks after planting. Ten plants were tagged to determine the growth and yield parameters. Data collected were subjected to Analysis of Variance using SPSS 16.00 version and mean separation was done using Duncan Multiple Range Test. It was discovered that treatments containing a combination of N:P:K, urea and *gliricidia sepium* (T₉) gave the best in terms of growth parameter and yield on site 1 while on site 2 a combination of N:P:K, urea and *Aspilia africana* (T₈) gave the best. This shows the okra responds well to applications of organic residues together with inorganic fertilizers.

Introduction

Okra is a vegetable crop that belongs to the genus *Abelmoschus*, family *Malvaceae* and has two main species: *Abelmoschus esculentus* (L.) Moench and *Abelmoschus caillei*. Okra is a heat-loving vegetable in the Hibiscus family. It is cultivated in tropical, subtropical and warm temperate regions around the world [10] and plays an important role in the human diet by supplying protein, fats, minerals and vitamins that are usually deficient in the sample food [5]. The nutritional importance of okra pod has reawakened interest in bringing the crop into commercial production. Despite the nutritional value of okra, its optimum yields (2-3tha⁻¹) and quality have not been attained in the tropical countries partly because of a continued decline in soil fertility [4]. Okra (*Abelmoschus esculentus* L. Moench) was domesticated in West and Central Africa, but is now widely cultivated throughout the tropics primarily for local consumption. In Nigeria, it ranks third in terms of consumption and production area following tomato and pepper [6]. The green pods are rich sources of vitamins, calcium, potassium, and other minerals [5]. At maturity, fruits turn brown and split into segments, only the tender, unripe fruit is eaten. Okra is an allopolyploid of uncertain parentage (proposed parents include *Abelmoschus ficulneus*, *A. luherculatus* and a reported "diploid" form of okra). Truly wild (as opposed to naturalized) populations are not known with certainty and the species may be a cultigen. Okra grows best at temperatures between 75 and 90°F and should not be planted in the spring before the soil temperature is about 65°F at the 4-inch depth [2]. The optimum soil temperature or seed germination is 70 to 95°F. The crop can be grown on all soil types, although sandy loam soils of high organic matter are the most desirable. It is important that the soil be well-drained. Okra is plant in full sun for best productivity [1]. It requires a warm, humid condition to produce an abundant crop. It can also be sensitive to salt spray; however, proper fertilizing will help maximize the number of fruits.

Tropical soils are adversely affected by suboptimal soil fertility and erosion, causing deterioration of the nutrient status and change in soil organism populations [17]. Use of inorganic fertilizers can improve crop yields, but its use is limited due to scarcity, high cost, nutrient imbalance and soil acidity [9]. Use of organic manures like poultry manure as a mean of maintaining and increasing soil fertility has been advocated because nutrients contained in manure are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crops yield [12]. More so, Green manure has a milder smell than the dung of carnivores or omnivores, making it easy to work with [11].

The effects of fertilizer on the growth and yield of okra had been reported in various studies [16, 14]. In the experiment conducted by Uka et al. [15] on the relative effects of inorganic and organic fertilizer on the growth of okra, it was observed that both fertilizer types produced significantly higher value for plant height, fresh weight, leaf area and dry weight compared to the control without fertilizer. The continuous use of mineral fertilizer in tropical soils which had been associated with reduced crop yield, increased soil acidity and nutrient imbalance necessitated investigation on the combination of organic materials and mineral fertilizer in fertilizer management to improve soil fertility [8]. Organic residues are considered as good sources of nutrient to improve soils. Compared to manures, these residues are found around farmyards and edges of roads, and if properly managed can improve soil fertility without the concern of transportation.

The nutritional importance of okra pod has reawakened interest in bringing the crop into commercial production. Despite the nutritional value of okra, its optimum yields ($2\text{--}3\text{ t ha}^{-1}$) and quality have not been attained in the tropical countries partly because of a continued decline in soil fertility [4]. Therefore, the objective of this study is to determine the effect of selected organic residues and inorganic fertilizer on okra performance.

Materials and Methods

Experimental Site Description

The study was conducted between January and July 2015 at the research and Teaching farm of Federal University of Technology Akure. The location has a bimodal rainfall of 1250 to 1460 mm with mean annual rainfall of 1367 mm. Temperature is almost uniform throughout the year $23\text{--}32^{\circ}\text{C}$ with little deviation from mean annual of 27°C . The mean total sunshine hour is about 2000 hours with mean annual radiation of about $130\text{ kcal cm}^{-3}\text{ year}^{-1}$. The area falls within the high forest zone where the rich tropical forests once thrived. The location has a tropical humid climate with distinct wet and dry seasons.

Land Preparation and Experimental Design

The site was cleared, measured out, pegged and beds were constructed manually with hoe. The area used was measured to be 28m by 11m in size having a total of 27 plots. Each plot measured 2m by 2m. The experimental field was made up of three blocks with 1m Alleyway within plots. The experiment was laid out in a Randomized Complete Block Design with each treatment replicated three times.

Treatments

The treatments tested with application rates were:

1. T_1 = Control
2. T_2 = 6 t ha^{-1} *Aspilia africana*
3. T_3 = 6 t ha^{-1} *Gliricidia sepium*
4. T_4 = 75 kg ha^{-1} NPK
5. T_5 = 75 kg ha^{-1} NPK + 6 t ha^{-1} *Gliricidia sepium*
6. T_6 = 75 kg ha^{-1} NPK + 6 t ha^{-1} *Aspilia africana*
7. T_7 = 75 kg ha^{-1} NPK + 50 kg ha^{-1} Urea
8. T_8 = 6 t ha^{-1} *Aspilia africana* + 75 kg ha^{-1} NPK + 50 kg ha^{-1} Urea
9. T_9 = 6 t ha^{-1} *Gliricidia sepium* + 75 kg ha^{-1} NPK + 50 kg ha^{-1} Urea

Planting and Cultural Practices

The variety of okra used for the experiment was lady finger; the seeds were purchased at the Agricultural Development Program Headquarter (ADP.) Akure. The seeds were planted at the rate of three seeds per hole with a spacing of 60cm by 45cm. Two weeks after planting (2wap), the seedlings were thinned to one plant per stand.

Treatments were applied two weeks after planting, 75kg of NPK was used as against the recommended rate of 150kg ha^{-1} proposed by Omotoso and Shittu [13]. This is done so as to see if the combination of NPK at the rate 75kg ha^{-1} with the other treatment will supply the deficit. Manual weeding was done twice throughout the duration of the experiment. Ten plants per plot were selected and tagged to determine the growth and yield parameters. The growth parameters assessed included plant height measured with the use of meter rule, stem girth measured with the use of vainer caliper, number of leaves was counted, leaves length measured with the use of meter rule. Successive harvesting was done five days interval as fruits reached marketable size. The number of fruits was counted on each occasion and fresh pod weight obtained to determine yield.

Analysis of Data

All data collected during the experiment were subjected to statistical analysis of variance (ANOVA) to determine the level of significance between the treatments using Statistical Package for the Social Science (SPSS) software version 16.00. Means of significant treatments were further separated using Duncan multiple range test (DMRT) $P \leq 0.05$.

Results

Pre-Planting Soil Chemical Properties

Table 1 shows pre-planting soil chemical soil analysis. The pH of the experimental soils varied between 5.13 to 5.78, total N 0.11 to 0.28%, available P 7.20 to 6.47 mg kg $^{-1}$, exchangeable K 0.08 to 0.13, Ca 1.8 to 2.6, Mg 0.05 to 1.00 cmol/kg, and organic matter (OM) 1.32 to 2.21%. The soil is acidic, low in N, exchangeable K and OM [3].

Effect of Organic Mulch and Inorganic Fertilizer on Plant height (cm) and Stem girth (cm) of okra

Table 2 and 3 present the effect of Organic Residue and Inorganic Fertilizers of plant height and stem girth of okra plant respectively. The same trend was observed for both plant height and girth at both sites. Through the growth period of the okra plant, T₉ recorded the tallest plant with the widest girth while T₁ (control) gave the lowest. However, T₅ and T₈ were not significantly different from the T₉. This phenomenon is as a result of the availability of N in the soil. N is responsible for proper vegetative growth of plant and the treatment combination (T₉, T₈, T₅) made N readily available throughout the growth period of the plant.

Table 1. Pre-planting soil properties.

Soil properties	Experimental sites	
	Site 1	Site 2
Sand (%)	62.80	60.80
Silt (%)	16.00	14.00
Clay (%)	21.20	25.20
Bulk Density (g/cm ³)	1.54	1.48
pH	5.78	5.13
Organic matter (%)	2.64	2.28
Total nitrogen (%)	0.11	0.28
Available P(mg/kg)	7.20	30.86
Exchangeable K(cmol/kg)	0.15	0.12
Exchangeable Ca(cmol/kg)	2.00	2.10
Exchangeable Mg(cmol/kg)	0.90	1.00

Table 2. Effect of Organic Mulch and Inorganic Fertilizer on plant height (cm) of okra at weeks after treatment application.

Treatment	SITE 1			SITE 2		
	4	6	8	4	6	8
T1	30.78d	41.13c	45.00c	32.13c	40.31c	45.93c
T2	36.70c	47.39bc	51.90bc	36.21bc	48.09ab	51.62bc
T3	37.30c	48.27ab	52.00b	37.61bc	47.32b	51.02bc
T4	39.00b	49.07a	53.53b	37.34bc	47.38b	52.87bc
T5	38.13b	48.77ab	55.87ab	39.09ab	49.10a	53.21ab
T6	35.14bc	47.49b	52.17b	36.12bc	48.13ab	53.06ab
T7	40.03ab	47.72b	52.32b	38.17b	46.93bc	51.13bc
T8	40.19ab	48.58ab	54.11ab	39.11ab	48.09ab	52.09b
T9	41.07a	48.76b	56.12a	40.59a	49.01a	54.14a

Each Value is a mean of three replicates. Data followed by the same alphabet along the columns are not significantly different at $p=0.05$ using Duncan's Multiple Range Test (DMRT)

Table 3. Effect of Organic Mulch and Inorganic Fertilizer on stem (cm) girth of okra at weeks after treatment application.

Treatment	SITE 1			SITE 2		
	4	6	8	4	6	8
T1	0.32d	0.40c	0.44c	0.30c	0.39c	0.42c
T2	0.38c	0.52a	0.54ab	0.38b	0.51a	0.54ab
T3	0.39c	0.48ab	0.52b	0.38b	0.49ab	0.55a
T4	0.40bc	0.48ab	0.55ab	0.41ab	0.48ab	0.52ab
T5	0.45a	0.47b	0.56a	0.43a	0.48ab	0.54ab
T6	0.41ab	0.49ab	0.55ab	0.37b	0.47b	0.53b
T7	0.42ab	0.47b	0.55ab	0.43a	0.47b	0.54ab
T8	0.45a	0.51a	0.56a	0.43a	0.49ab	0.54ab
T9	0.45a	0.52a	0.56a	0.43a	0.50a	0.55a

Each Value is a mean of three replicates. Data followed by the same alphabet along the columns are not significantly different at $p=0.05$ using Duncan's Multiple Range Test (DMRT)

Effect of Organic Mulch and Inorganic Fertilizer on number of leaves and Leaf Length (cm) of okra

Table 4 and 5 present the effect of Organic Residue and inorganic fertilizer on leaf number leaf length (cm) of okra plants respectively. The same trend was observed at the two sites, T₇ recorded the longest leaf while T₁ (control) gave the shortest leaf. The second longest leaf and highest leaf number came from T₉ but there was no significant difference between T₇ and T₉. Nitrogen aids vegetative growth of plants and the application of Urea which is a single or straight fertilizer combined with NPK makes Nitrogen available in the soil. The okra plant thereby had supply of N for metabolism from the T₇. This agrees with the findings of R.L. Walker et al. [7] who stated that nitrate only tended to accumulate in plant tissues when its supply is adequate. By comparison, plants forced to rely solely on their internal reserves were never able to mobilize and redistribute N between tissues quickly enough to prevent reductions in growth rate as their tissue N reserves declined.

Table 4. Effect of Organic Mulch and Inorganic Fertilizer on number of leaves of okra at weeks after treatment application.

Treatment	SITE 1			SITE 2		
	4	6	8	4	6	8
T1	14.67b	20.57c	25.73c	12.89b	16.01c	22.00c
T2	17.39ab	23.28bc	27.84b	14.81ab	19.58bc	25.12bc
T3	19.31a	24.12b	29.91ab	18.48a	23.87b	28.01b
T4	19.33a	25.34ab	29.00ab	19.67a	25.11a	28.66b
T5	19.33a	25.23ab	29.00ab	18.72a	24.14ab	30.10a
T6	20.67a	26.81a	30.00a	19.51a	24.36ab	29.14ab
T7	20.72a	25.37ab	29.18ab	18.93a	23.69b	29.28ab
T8	20.00a	26.04a	29.33ab	20.03a	23.69b	29.31ab
T9	20.73a	26.17a	30.19a	19.79a	25.42a	29.68ab

Each Value is a mean of three replicates. Data followed by the same alphabet along the columns are not significantly different at $p=0.05$ using Duncan's Multiple Range Test (DMRT)

Table 5. Effect of Organic Residue and Inorganic Fertilizer on Leaf Length (cm) of okra at weeks after treatment application.

Treatment	SITE 1			SITE 2		
	4	6	8	4	6	8
T1	28.97e	49.23d	75.33d	22.11d	40.27e	75.11c
T2	35.48d	54.57cd	88.60c	37.27cd	48.33d	75.19c
T3	35.69d	61.13c	86.19c	34.26cd	53.47cd	85.40bc
T4	46.16c	71.57bc	93.53ab	42.62c	61.66c	92.39b
T5	55.12bc	80.30b	93.47ab	49.83c	80.01bc	93.17ab
T6	48.45c	83.31ab	93.51ab	49.84bc	82.11b	94.64bc
T7	59.10ab	86.42a	99.73a	57.68a	89.46a	95.6a
T8	58.81b	86.72a	93.11b	58.36a	82.91b	92.48bc
T9	59.93a	84.78ab	95.41ab	51.9b	83.00ab	94.89a

Each Value is a mean of three replicates. Data followed by the same alphabet along the columns are not significantly different at $p=0.05$ using Duncan's Multiple Range Test (DMRT)

Effect of Organic Mulch and Inorganic Fertilizer on the yield of okra

Fig. 1 shows the effect of organic residues and inorganic fertilizers on the yield of okra plant on both site 1 and site 2. The same trend was observed on both sites with the control (T1) recording the lowest yield among the treatments. The highest yield on site 1 is T₉ (6 t/ha *Gliricidia sepium* + 75 kg ha⁻¹ NPK + 50 kg ha⁻¹ Urea) while on site 2, T₈ (6 t ha⁻¹ *Aspilia africana* + 75 kg ha⁻¹ NPK + 50 kg ha⁻¹ Urea) gave the highest. However, the other treatments also did better than the control. Organic residues have the ability to create conducive environs for crops to thrive better apart from their ability to also supply certain nutrients to soil. They could improve soil structure, reduces evaporation, thereby increasing moisture availability as well as regulate soil temperature. All of these coupled with the NPK application gave T₈ and T₉ an edge over other treatment combinations. Fig. 2 compares the yield of okra at both sides. From the chart, site 1 gave higher yield than site 2 with T₅, T₆, T₇, T₈ and T₉. This could be because the soil at site 2 has a higher clay content than set 1, clays are colloidal materials and have the ability to hold on to soil nutrients particularly P and exchangeable cations. When this happens, the nutrients are no longer available for plant use. This result confirms the findings of Akande et al. [8] and Uddin et al. [18] that application of organic material could ameliorate soil nutrients to improve crop production.

Figure 1. Effect of Organic Mulch and Inorganic Fertilizer on yield of okra.

Figure 2. Comparison between Site 1 and Site 2 on yield of okra.

Conclusion

After the investigation, it was concluded that okra responds well to the application of organic residues of *Gliricidia sepium* and *Aspilia africana* particularly when combined with inorganic fertilizers. The inorganic fertilizers make nutrient available in fast and large amount which is important for plant at the early stage of growth, while the organic residues create a favorable condition for plant to thrive well and also release nutrients slowly which can be used by plant at a later period of development.

Conflict of Interest

The authors declare that there is no conflict of interest.

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