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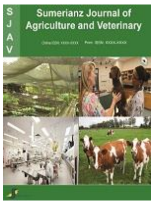

Original Article Open Access

Growth and Yield Responses of Okra (*Abelmoscus esculentum L.*) As Influenced By Sawdust Ash and Ammonium Nitrate

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Abstract

In recent years, there are lots of soil problems associated with the use of chemical or minerals fertilizers and also the cost of mineral fertilizers, insufficiency of the commodity supply as well as the distribution have not been of advantage of the local farmer. Hence this study tends to investigate the effects of Sawdust Ash and Ammonium Nitrate on the performance of Okra (*Abelmoscus esculentum L.*) in Lanlate. Field trials were conducted at Teaching and Research Farm of The College of Education, Lanlate, Southwest Nigeria in 2016 and 2017. There were six treatments replicated three times in a Randomized Complete Block Design (RCBD). Treatments were applied three weeks after planting by ring method with Ammonia Nitrate and Sawdust Ash mixed. Soil chemical properties, plant nutrients content, growth and yield parameters were evaluated. Data were analyzed using Analysis of Variance (ANOVA) and Duncan Multiple Range Test was used to compare the treatment means. The test soil indicated that it was marginal in organic matter, inadequate in available P and slightly acidic. SDA and its combinations with reduced rates of Ammonium Nitrate significantly increased number and weight of fruits. The 60 $kgha^{-1}$ urea + 4.5 t/ha^{-1} SDA increased pod weight significantly in both years. Relative to control, Urea alone, 180 kg/ha^{-1} AN + 1.5 t/ha^{-1} SDA, 120 kg/ha^{-1} AN + 3.0 tha^{-1} SDA, 60 kg/ha^{-1} AN + 4.5 t/ha^{-1} SDA, and 6.0t/ha^{-1} SDA increased pod weight by 29, 32, 37, 52 and 39% respectively. Combination of 60kg/ha^{-1}AN + 4.5t/ha^{-1}SDA is recommended.

Keywords: Okra; Sawdust ash; Ammonium nitrate; Growth; Yield.

1. Introduction

Okra (Abelmoscus esculentum L.) is an annual herb and vegetable crop grown throughout the tropical and subtropical parts of the world either as the sole crop or intercrop with yam and maize [1]. Okra is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. It is among the most heat- and drought-tolerant vegetable species in the world—but severe frost can damage the pods and will tolerate poor soils with heavy clay and intermittent moisture.

Okra (*Abelmosschus esculentus* L. Moench) belongs to the family Malvaceae. It is one of the prominent vegetable, crops grown in Nigeria and it is widely cultivated in the tropics. Okra is important because of its nutritive values that are present in the leaves and fruits [2]. Despite the nutritive values of okra, its production is very low in most developing countries. Most farmers in developing countries depend mainly on natural fertility of the soil and in addition, invest considerable labour in land preparation and weed control, so as to achieve a reasonable yield of the crop. [3]

Okra seeds germinate in warm soils with temperatures above 16^0c. However, a wide range of soil types give economic yield but well drained sandy loamy soils with reserves of the major elements are ideal [4]. Okra does not grow well on clay soils, in swampy areas or on acid soils. It can be grown on ridges, mounds and heaps as well as on zero-tilled and manually cleared soils [5]. Okra likes plenty of sunshine and does not do well in the shade. It can tolerate high temperature, but heat coupled with low humidity slows down its growth considerably [2].

Inorganic fertilizer (chemical fertilizer) provides readily available nutrients for plant uptake and growth, while its organic counterpart besides nutrients supply to crop, also improves soil physic-chemical condition, thereby increasing soil organic matter content.

Total dependence on chemical fertilizer for sustaining soil fertility and high crop yields in humid tropical zone of the world has not given desirable results. Problems associated with continuous use of chemical fertilizer include nutrient inbalance due to insufficient nutrient supply increased soil acidity, degradation in soil physical status and loss of organic matter. [1]. Also, Fakorede [6] inserted that inorganic fertilizer is not efficiently used due to it unavailability at the right time and insufficient quantity. [7] stressed that the wide gap existing between the farmers and the researchers might cause inefficient use of farm input such as fertilizers because many farmers would not receive up to date knowledge on the use of such input.

In general, problems associated with continuous use of chemical fertilizer include nutrient inbalance due to nutrients not supplied, increased soil acidity, degradation in soil physical status and loss of organic matter [8]. Hence it is necessary to investigate into available, cheap organic manures to combat these soil management problems.

Judicious application of inorganic fertilizer along with organic manure is one of the concept gaining importance as it forms the integrated soil fertility management. The combined use of organic and inorganic fertilizers reduced the bulk of organic fertilizer required for optimum crop production and also prevents rapid degradation of the soils as a results of continuous use of inorganic fertilizers [9]

The sawdust is an easily available cheap organic waste which is abound at over 2000 sawmilling plants all over Nigeria. The dust contains nutrients such as P, K, Ca, Mg, Cu, Zn, Mn and Fe [10]. The piles of sawdust are incinerated to pure ash. Because of the acidic nature of soil in Southern Nigeria the sawdust ash has the potential of being used to control soil acidity and supply nutrients to crop [11]. SDA increased Yield of Cowpea, Okra, Tomato and Uptake of P,K,Ca and Mg. Also, SDA contained 1.16%N, 0.04%P, 2.8%K, Mg 0.07% and Ca 0.35%. [11].

Plant derived ash is an agricultural and domestic waste which has been proved to be an effective source of nutrients for crops. It is a liming and fertilizer material. It also improved soil physical condition [12]. Ash derived from burnt plant residue is a source of plant nutrients [10] which can be used alone or in combination with N-rich chemical fertilizer or organic manure such as that of goat and poultry. The majority of the Southern Sudan recognizes that accumulations of wood ash provide valuable sites for cultivating ecologically specialized plants . Soils in the area are largely acidic, so K. can become a limiting factor. With no synthetic fertilizer available, wood ash has a clear and significant effect on the growth and yield of many crops [13]. Ash is composed of many major and minor elements needed by the tree for plant growth. Since most of these elements are extracted from the soil and atmosphere during the tree's growth cycle, they are elements that are common in our environment and are also essential elements in the production of crops and forages The integrated application of organic and inorganic nutrient sources rather than total dependence on any of the sources is expected to ensure reduction in expenditure on chemical fertilizers, a more balanced plant nutrition and control of soil acidity. Since sawdust ash is a waste which poses environmental concern, its combined use with chemical fertilizer in crop production will assist in environmental sanitation. Due to increasing number of saw milling industries in Nigeria, sawdust is being daily generated and burnt. There is urgent need to study the use of sawdust ash waste for soil improvement and as fertilizer and liming material. Hence, the objective of this study is to evaluate the effect of combined application of Sawdust ash and its combined application with Ammonium nitrate on the growth and pod yield of okra plant nutrients composition.

2. Materials and Methods

Experiments was conducted at the Teaching and Research Farm of The College of Education, Lanlate, Southwest, Nigeria in 2016 and 2017 cropping seasons to study the effects of Sawdust Ash (SDA) on soil and okra pod nutrients composition when used alone or combined with Ammonium nitrate. Lanlate lies between latitude 7^0 30'N and Longitude 3^0 52'E in the tropical rainforest belt f Nigeria. There are two rainy seasons; one from April to July (early season) and the other from mid-August to November (late season). Annual average minimum and maximum temperatures are 24.80^0C and 28.10^0C respectively. The mean relative humidity is about 75%. The soil at the site is classified as an alfisol (Oxic tropuldalf) according to [14]. There were six treatments replicated three times in a Randomized Complete Block Design. Treatments were applied three weeks after planting by ring method with Ammonium nitrate and SDA mixed. The treatments were namely; The Control (no AN, no SDA), 240kg/ha^{-1} AN alone, 4.5t/ha^{-1} SDA + 60kg/ha^{-1} AN, 3.0t/ha^{-1}SDA+ 120kg/ha^{-1} AN, 1 .5t/ha^{-1}SDA + 180 kg/ha^{-1}AN, 6.0 t/ha^{-1}ash alone. Each of the 18 plots was 3m by 3m (9m^2) in size and seeds were planted at 0.60m X 0.90m. Plant growth and yield parameters taken at 3, 6, 9 and 12 weeks after treatments (WAT) included plant height, stem girth, number of leaves, number of branches, and grain weight. At termination of experiment 14 weeks after treatment, root weight, leaf weight and total fresh matter weight were taken. Data were analysed using Analysis of Variance (ANOVA) to determine the effects of treatments on the parameters measured. Duncan Multiple Range Test was used to compare the treatment means.

3. Results

Table 1 shows the pre-planting soil analysis. It was loamy sand with a pH (H_2O) of 6.6, total N 0.09%, available P 5.6 mg/kg, organic C 1.73%, organic matter (OM) 2.62%. The respective values for exchangeable K, Ca, Mg and Na were 0.25,2.6,2.1 and 0.18 cmol/kg. The OM falls within 0.5-4.0% established for soils of southwestern Nigerian [15] but lower than critical level of 3% specified by Akinrinde and Obigbesan [16]. The total N, available P and exchangeable Ca fell below critical level levels of 0.15% N, 10.0mg/kg available P, 2.0 cmol/kg exchangeable Ca and 0.4 cmol/kg established for crop production in southwestern Nigeria by Akinrinde and Obigbesan [16]. Therefore, response to the applied fertilizers is expected.

Table-1. Initial soil analysis of experimental site at Lanlate

Properties	Values
pH (H_2O)	6.50
Organic Matter (%)	2.62
Total Nitrogen (N) g/kg	0.09
Available Phosphorous (P) (mg/kg)	5.60
Exchangeable Calcium (cmol/kg)	2.60
Exchangeable Magnesium (Mg) (cmol/kg)	2.10
Exchangeable Sodium (Na) (cmol/kg)	0.18
Exchangeable Potassium (K) (cmol/kg)	0.25
Sand (%)	81.20
Silt (%)	5.60
Clay (%)	13.20
Texture	Loamy sand

Data on growth parameters of okra as influenced by Urea (U), Sawdust Ash (SDA) and their combined use at different rates (table 2 and 3) shows that Okra plant height was increased in 2016 only at 180kg/ha^{-1} AN + 1.5t/ha^{-1} SDA and 120kg/ha^{-1} AN + 3.0t/ha^{-1} SDA. In 2017, the plant height was increased at 120kg/ha^{-1} AN + 3.0t/ha^{-1} SDA only. Relative to control, Urea, SDA and their combined use at reduced rates increased number of flowers in 2016 and 2017.

Table-2. Effects of Sawdust Ash (SDA) and Ammonium Nitrate (AN) on Growth parameters of Okra in 2016

Treatment	Plant height (cm)	Stem girth (cm)	No of leaves per plant	No of flower per plant
Control	114.37ab	8.03ab	21.78ab	1.11b
240kg/ha^{-1}AN	98.82ab	9.27a	19.11ab	2.78a
1.5t/ha^{-1} SDA +180kg/ha^{-1} AN	106.53ab	9.42a	19.22ab	1.56ab
3.0t/ha^{-1} SDA + 120k/ha^{-1} AN	123.67a	8.56ab	26.44ab	2.11ab
4.5t/ha^{-1} SDA + 60kg/ha^{-1} AN	86.33b	7.17b	31.89a	1.44ab
6.0t/ha^{-1} SDA	99.56ab	7.71ab	15.33b	2.00ab

Means followed by the same letter within each column are not significantly different (P = 0.05) as indicated by Duncan's Multiple Range Test

Table-3. Effects of Sawdust Ash (SDA) and Ammonium Nitrate (AN) on Growth parameters of Okra in 2017

Treatment	Plant height (cm)	Stem girth (cm)	No of leaves per plant	No of flower per plant
Control	122.97	8.13	25.26ab	0.78a
240kg/ha^{-1}AN	114.67	9.39	16.78ab	1.33a
1.5t/ha^{-1} SDA + 180kg/ha^{-1}AN	96.18	7.87	19.44b	1.56a
3.0t/ha^{-1} SDA + 120k/ha^{-1} AN	124.97	7.27	21.44ab	1.89a
4.5t/ha^{-1} SDA + 60kg/ha^{-1} AN	112.48	7.98	30.22a	1.00a
6.0t/ha^{-1} SDA	101.32	8.28	20.33b	1.00a

Means followed by the same letter within each column are not significantly different (P = 0.05) as indicated by Duncan's Multiple Range Test

Ammonium nitrate and SDA alone and combinations of their reduced rates increased number of fruits in 2012. The SDA and combinations at 60kg/ha^{-1} U + 4.5t/ha^{-1} SDA and 120kg/ha^{-1} U + 3.0t/ha^{-1} SDA increased number of fruits significantly in 2017 (Table 4 and 5).

In 2016, SDA, 60kg/ha^{-1} AN + 4.5t/ha^{-1} SDA and 120kg/ha^{-1} AN + 3.0t/ha^{-1} SDA significantly increased fruit weight. In 2017, Urea, SDA alone and combinations of their reduced rates increased fruit weight. It was 60kg/ha^{-1} AN + 4.5t/ha^{-1} SDA that increased fruit weight significantly in both years. The mean fruit weight per plant recorded for the control, Urea, 180kg/ha^{-1} AN + 1.5t/ha^{-1} SDA, 120kg/ha^{-1} AN + 3.0t/ha^{-1} SDA, 60kg/ha^{-1} AN + 4.5t/ha^{-1} SDA and 6.0t/ha^{-1} SDA were 38.4, 49.5, 50.5, 52.6, 58.4 and 52.9g/plant respectively. Relative to control, Urea, SDA, 180kg/ha^{-1} AN + 1.5t/ha^{-1} SDA, 120kg/ha^{-1} AN + 3.0t/ha^{-1} SDA, 60kg/ha^{-1} AN + 4.5t/ha^{-1} SDA and 6.0t/ha^{-1} increased fruit yield by 29, 32, 37, 52 and 38% respectively. The need for Urea in okra production could be reduced to 33.3% if adequate ash of 4.5t/ha^{-1} is combined with 60kg/ha^{-1} AN.

Table-4. Effects of Sawdust Ash (SDA) and Ammonium Nitrate (U) on Yield of Okra in 2016

Treatment	No of Fruits per plant	Fruits weight (g)
Control	2.2b	35.7c
240kg/ha^{-1}AN	3.2a	37.1c
1.5t/ha^{-1} SDA + 180kg/ha^{-1} AN	3.3a	32.6c
3.0t/ha^{-1} SDA + 120k/ha^{-1} AN	3.6a	42.1b
4.5t/ha^{-1} SDA + 60kg/ha^{-1} AN	2.8b	51.4a
6.0t/ha^{-1} SDA	3.0a	42.0b

Means followed by the same letter within each column are not significantly different (P = 0.05) as indicated by Duncan's Multiple Range Test

Table-5. Effects of Sawdust Ash (SDA) and Ammonium Nitrate (U) on Yield of Okra in 2017

Treatment	No of Fruits per plant	Fruits weight (g)
Control	6.6c	41.1b
240kg/ha^{-1}AN	6.0c	61.9a
1.5t/ha^{-1} SDA + 180kg/ha^{-1} AN	5.0c	68.3a
3.0t/ha^{-1} SDA + 120k/ha^{-1} AN	7.6b	63.0a
4.5t/ha^{-1} SDA + 60kg/ha^{-1} AN	7.4b	65.3a
6.0t/ha^{-1} SDA	9.2a	63.7a

Means followed by the same letter within each column are not significantly different (P = 0.05) as indicated by Duncan's Multiple Range Test.

4. Discussions

Its combined use with Urea is expected to ensure a more balanced nutrition since ash has low N concentration. The N is volatilised during burning of wood or plant material.

The balance plant nutrition is expected to influence positively plant growth and yield as it is found in this work. It was found that combination at 60kg/ha^{-1} AN + 4.5t/ha^{-1} SDA increased fruit weight significantly and gave the highest mean fruit weight. The SDA, Urea and their combinations increased number of flowers, fruits and fruit weight significantly.

A number of studies conducted in southern and northern Nigeria also showed that N, P and K fertilizers increased yield of okra [17-19]. In the study with tomato, Ewulo, *et al.* [20] found that combined application of 1.5t/ha sawdust ash (SDA) and 180kg/ha urea increased fruit yield by 67% at Akure Southwest Nigeria. Also integrated application of animal manure and inorganic fertilizers or sole use of manure were found to be beneficial in okra production [21-25]. Organic manure was also found to improve organoleptic property of okra fruit [24].

Aside from its liming effect, it was found in the present work that SDA significantly increased soil P, K, Ca and Mg. this is consistent with analysis data given for the material which show that it contained macronutrients [26].

The increase in okra yield recorded in this work aligns with the finding of Moyinjesu and Ojeniyi [27] that wood ash and sawdust ash at 6t/ha increased fruit count of okra by 385 and 185% respectively. Wood ash and other types of plant derived ashes were also found to increase organic matter, N, P, K, Ca and Mg in soil which were made available for uptake of crops such as cocoa [28]. They increased plant N, P, K, Ca and Mg contents and growth of okra.

Adekunle [29] also studied effects of SDA for increasing nutrients availability and performance of okra. He observed that manures such as poultry, cow dung manure and SDA increased growth of okra and reduced population of nematodes. Abdulraheem, *et al.* [10] also concluded that performance of sorghum and nutrients availability can be significantly increased by combining reduced levels of urea and sawdust ash (SDA). Combination of 1.5t/ha SDA + 180kg/ha Urea maximized uptake of N, and yield of sorghum. Additions of SDA to urea increased soil OM, N, P, K, Ca, tissue K and Mg. The use of SDA reduced need for inorganic fertilizers in sorghum cultivation. [10]

Owolabi, *et al.* [11] conducted field experiment and found that SDA at 3 to 12t/ha increased fruit weight of okra and plant P, K, Ca and Mg concentrations. Being a pH sensitive plant, the liming Effects of ash is also advantageous to okra.

The highest yield given by 60kg/ha^{-1} AN + 4.5t/ha^{-1} SDA in both years of study can be adduced to the finding that the treatment significantly increased P and Ca in plant and gave highest plant N and P. Nutrients such as N and P have been found to improve performance of okra significantly [30, 31].

The SDA significantly increased plant P, Ca and Mg. Combination 60kg/ha^{-1} AN + 4.5t/ha^{-1} SDA significantly increased P and Ca in plant and gave highest plant N and P. it gave highest yield increase of 52%. This affirmed the work of Abdulraheem, *et. al.* 2017a that In terms of nutrients uptake, SDA alone or with combined with Ammonium nitrate or NPK was found to increase P, Ca and Mg concentrations significantly in okra plant. Its combined use at 50%SDA + 50% AN and 50%SDA + 50%NPK significantly increased plant P and Ca. The latter combination also gave highest plant N and P among combined treatments. This affirms that SDA is a source of nutrients for crop uptake. [32-34].

5. Conclusion

It is concluded that integrated application of sawdust ash and Urea of reduced rates increased nutrients availability to okra, especially Ca and Mg which also reduced soil acidity to which okra is sensitive. The integrated use also reduced need for Urea to one third thus reducing fertilizer rate. The combined application of Urea and sawdust ash is recommended for okra production.

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