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Research Paper

Performance of Finger Millet (*Eleusine corocana* L. Gaertn) as Influenced by Nutrient Sources in the Southern and Northern Guinea Savanna, Nigeria

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Millets are major food and feed sources in the developing world especially in the semi-arid tropical regions of Africa and Asia. Millets are resilient to extreme environmental conditions especially to inadequate moisture and are rich in nutrients. Finger millet is a vital component in the farming systems of many parts of Nigeria. A multi-location trial was conducted at the Teaching and Research Farm of the Department of Crop Production, Federal University of Technology, Gidan Kwano Campus Minna and on the Nigeria Prison Farm, Kaduna located in the Southern and Northern Guinea Savanna Zone of Nigeria. The trial was conducted to evaluate the performance of finger millet (*Eleusine corocana* L. Gaertn) as influenced by nutrient sources" in the 2013 wet season. The treatments consisted of 5 nutrient sources; recommended N:P:K fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}), poultry droppings (2 t/ha^{-1}), cow dung (4.5 t/ha^{-1}), horse dung (6.0 t/a^{-1}) and a control. The treatments were laid out in a randomized complete block design with three replications. The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the longest leaves, tallest plants, widest leaves, highest leaf area index, longest internodes, shortest number of days to 50% heading, longest fingers, highest number of fingers, highest number of seeds, heaviest spikes and highest grain yield. Application of poultry droppings (2 t/ha^{-1}) produced the heaviest seeds. Grain yield correlated positively and significantly with leaf length, internodes length plant height, leaf area index, number of fingers, length of fingers, seed weight compared with other growth and yield attributes. Finally, from the results, farmers in the Southern and Northern Guinea Savanna should be encouraged to grow finger millet with the application of the recommended dose of organic fertilizer for enhanced grain yield of finger millet.

Key words: Finger millet; Multi-location; Poultry droppings; Cow dung and Horse dung.

INTRODUCTION

Finger millet is thought to have been domesticated at the beginning of the Iron Age in Africa and was introduced into India 3000 years ago before spreading to South-East Asia. It is widespread in warm temperate regions from Africa to Japan and Australia, but can also be grown in colder regions as far north as Northern Ireland, during summer (Heuzé and Tan, 2015).

It is a cereal grass grown mostly for its grain. Finger millet is a robust, tufted, tillering annual grass, up to 170 cm high (FAO, 2012; de Wet, 2006; colder regions as far north as Northern Ireland, during Quattrocchi, 2006). The inflorescence is a panicle with 4-19 finger-like spikes that resembles a fist when mature, hence the name finger millet (de Wet, 2006; Quattrocchi, 2006). The spikes bear up to 70 alternate spikelets, carrying 4 to 7 small seeds (Dida and Devos, 2006). The seed pericarp is independent from the kernel and can be easily removed from the seed coat (FAO, 2012).

The global annual planting area of finger millet is estimated to be around 4-4.5 million hectares, with a total production of 5 million tons of grains, of which India alone produces about 2.2 million tons and Africa about 2 million tons.

The rest comes from other countries in South Asia (Mathur and Luigi, 2011). The important finger millet growing countries in Eastern and Southern Africa have been especially the sub-humid regions of Ethiopia, Kenya, Malawi, Tanzania, Uganda, DR Congo, Zambia and Zimbabwe. Similarly in South Asia the crop is largely grown in India, Nepal, and to some extent in Bhutan and Sri Lanka.

Finger millet is reported to be grown in both China and Japan to a limited extent (Mathur and Luigi, 2011). Nigeria with an average yield of 580 – 785 kg ha^{-1} accounts for about 44%production of this crop in the continent. Finger millet is grown in the Northern parts of Nigeria, mostly in combination with pearl millet. This plant, though not produced as much as other cereals in Nigeria, is an important crop due to its high nutritive value (Glew *et al.,* 2008). It is a rich source of Ca (0.344 %) for growing children and aged people. It is usually converted into flour, which is used for preparation of cake, puddings and porridge.

The straw of the plant are valuable fodder for both draught and mulch animals. It is wholesome food for diabetics (Gangaiah, 2012).

The millet is normally consumed in the form of flour-based foods such as *roti* unleavened pancake, stiff porridge, dumpling and thin porridge and each of these foods having their characteristics features (Malleshi, 2007). Finger millet, *E. coracana* L. is also known as ragi and mandua (India) (Chaturvedi and Srivastava, 2008). Traditionally, finger millet is processed either by malting or fermentation (Rao and Muralikrishna, 2001). Nutritionally, finger millet is good source of nutrients especially of calcium, other minerals and fibre. The proximate composition of finger millet is carbohydrate (72.6%), protein (7.7%), fat (1.5%), crude fiber (3.6%), ash (2.7%), calcium (344 mg $100gm^{-1}$), P 250 mg, Fe 6.3 mg, Mg 3.5 mg and Mn 130 mg. (Rao and Muralikrishna, 2001).

Farmers plant finger millet in small areas of 0.5 acres or less with no or inappropriate agronomic guidelines which leads to poor crop performance (Kute, 1995). For example, farmers in Chobosta Kenya, identified lack of suitable finger millet varieties and poor soils as major constraints to the production of this crop (Kute *et al.*, 1997). Poor soil nutrients and moisture status are the important constrains for higher productivity of finger millet (Jagathjothi *et al.,* 2008).

The use of chemical fertilizers has witnessed a decline in trend of usage due to its negative effects resulting on limitation of crop yield and mining of crops. This has also led to the degradation of the already fragile soils (Ali, 2005). Fertility improvement by inorganic fertilizer is currently out of the reach of the majority of peasant farmers due to high cost. This situation has forced most of the farmers to grow and produce cereals with poultry droppings or no fertilizer which reduces yield and quantity of cereals produced (Murwira and Kirchmann, 1993).

The recent increases in cost of inorganic fertilizers has triggered scientific interest towards the evaluation of organic fertilizers based on locally available resources, including crop residues, animal manure and green manures.

The overall amounts of nutrients released from organic amendments for crop uptake depends on the quality, the rate of application, the nutrient release pattern and the environmental conditions (Murwira and Kirchmann, 1993). The wise use of crop management practices which include the time of planting, frequency of tillage and the rate and time of fertilizer application is important particularly in the semi-arid regions where moisture is scarce.

Access to agricultural inputs such as improved seeds, fertilizer and chemicals as well as credit and markets is important for farmers.

Focus on soil fertility has shifted towards the combined application of organic matter and mineral fertilizers as a way to arrest the ongoing soil fertility decline in sub Saharan Africa. Organic manure has over time been used to improve soil fertility. Organic manures supply nutrient to the plants, improve soil structure, aeration and encourage good root growth. Also, it is understandable that all the essential nutrients required by plants are supplied by organic manures, although in small amounts (Ali, 2005). In this situation, the use of poultry litter which is readily available and can supply minimum amount of nutrients for cereal production is advisable. Various researches have been conducted on organic fertilizer but there is dearth of information on the use of poultry litter as a complement or substitute for inorganic fertilizer for soil fertility management (Udom and Bello, 2009), especially in finger millet production in Nigeria.

Rangaraj *et al.* (2007) reported that the application of organic manures (composted coirpith and farm-yard-manure each at 12.5 t ha^{-1}) influenced the soil availability of nutrients. Mandal *et al.* (1991) reported that the application of organic manures increases the N availability in the soil. In order to sustain the yield and reduce the dependency on inorganic fertilizer use, combined use of organic manures, bio fertilizers and fertilizers is very much essential (Kumar *et al.,* 2003). The objective of this study is to evaluate the influence of organic and inorganic soil nutrition on the productivity of finger millet.

MATERIALS AND METHODS

Study location

The experiment was conducted at the Teaching and Research Farm of the Department of Crop Production, Federal University of Technology Minna, (Latitude 9° 40'N and Longitude 6° 30'E) in the southern Guinea Savannah zone and at the Nigeria Prison Farms in Kaduna, (Latitude 10° 27' N and Longitude 7° 38' E) in the northern Guinea Savannah zone of Nigeria during the 2013 and 20214 cropping season.

Source of planting materials

The seeds of finger millet were obtained from local finger millet farmers in Kaduna.

Soil sampling

Soil samples were randomly collected from various points at the two experimental sites at the depth of 0-15 cm using an auger before land preparation. Samples from each field were bulked together to form a composite sample. The soil was then subjected to routine physical and chemical analysis using standard laboratory procedures as described by Black, (1965).

Organic manure analysis

Samples of each nutrient source (poultry droppings, cow dung and horse dung) were analyzed for their chemical properties using standard laboratory procedures.

Experimental design

The treatment consisted of nutrient source (N.P.K fertilizer 100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}, Poultry droppings at 2 t/ha^{-1}, cow dung at 4.5 t/ha^{-1}, horse dung at 6 t/ha^{-1} and a control without addition of nutrients). The treatments were laid out in a Randomized Complete Block Design (RCBD), replicated three times. The gross plot size was 4 m x 4.5 m (18 m^2) consisting of 6 ridges of 4 m long each while the net plot size was 4 m x 1.5 m (6 m^2) consisting of the 2 middle ridges of 4 m long each. Sowing was done two weeks after ridging with inter and intra-row spacing of 90 × 20 cm at the rate of 5 seeds per hole. The seedlings were thinned to two plants per stand at two weeks after emergence and empty stands were supplied one week after sowing.

Weeding

Weeding was done twice manually with a hoe at three and six weeks after planting.

FERTILIZER APPLICATION

Organic fertilizer application

After land preparation, the various organic manures (poultry droppings, cow dung and horse dung) at the prescribed rate were incorporated into the soil two weeks prior to seed sowing.

Inorganic fertilizer application

The inorganic fertilizer (at the recommended rate of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare) was applied by band method. The N component was applied in two split doses at 3 and 6 weeks after - WAS. A basal dose of 50 kg N, 50 kg P_2O_5 and 50 kg K_2O was applied at 3 WAS while the remnant 50 kg N was applied by top dressing at 6 WAS using urea (46%N) as source.

Harvesting

All the plants in the net plot were harvested manually by cutting the head. The crop was considered physically matured when 90% of the plant straw had turned from green to straw colour, then the heads were further dried in bundles, kept upright under the sun for two weeks before threshing and winnowing.

GROWTH PARAMETERS

Plant height (cm)

This was taken from the five tagged plants within each treatment net plot at 3, 6 and 9 WAS. The mean from the five plants were them determined and recorded.

Leaf length

The leaf length was determined at 3, 6 and 9 WAS. Twenty five leaves were measured in each treatment net plot from the five tagged plants, and the mean leaf length determined.

Leaf area

The leaf area was determined at 3, 6 and 9 WAS by the destructive method as described by Saxena and Singh, (1985) using the relation:
Leaf area = 0.75 (length x width)
Where, 0.75 = a constant

Twenty five leaves were measured in each treatment net plot from the five tagged plants, and the mean leaf area determined.

Table 1. Physico-chemical properties of experimental sites.

Parameters	Minna	Kaduna
Physical properties (g Kg^{-1})		
Clay	100	130
Silt	180	70
Sand	720	800
Textural	Sandy loam	Sandy loam
Chemical properties		
pH (H_2O)	5.6	6.80
Organic carbon (g kg^{-1})	2.6	0.56
Total Nitrogen (g kg^{-1})	0.48	0.33
Available phosphorus (mg kg^{-1})	10.2	13.96
Exchangeable bases		
Ca^{2+}	2.45	4.60
Mg^{2+}	2.33	0.80
K^{+}	0.08	0.12
Na^{+}	0.39	0.19
Cation Exchange Capacity (CEC) ($cmolkg^{-1}$)	5.25	5.71
Exchangeable Acidity ($cmolKg^{-1}$)		
$Al^{3+} + H^{+}$	1.1	1.3
Effective cation exchange capacity (ECEC)	6.35	3.09

Leaf area index

The leaf area index was determined at 3, 6 and 9 WAS using the formula:

$$LAI = \frac{\text{Leaf area}}{\text{Area occupieeed by plant}}$$ (Abuzar *et al.*, 2011)

Internodes length

This was taken from the five tagged plants within each treatment net plot at 3, 6 and 9 WAS. The mean from the five plants were then determined and recorded.

Statistical analysis

All data collected were subjected to an analysis of variance (ANOVA) using the Statistical Analysis System (SAS) package version 9.0 (2002). Treatment means were compared using Student Newman Keuls (SNK) at 5% level of probability. The magnitude and type of relationship between grain yield and some growth and yield attributes were determined using simple correlation analysis as described by Little and Hills (1987).

RESULTS AND DISCUSSION

Soil and organic nutrient sources analysis

Result of the physico-chemical analysis of the soils of both locations is shown on (Table 1). The result revealed that, the soils were sandy loam with slightly acidity level in Minna and fairly alkaline in Kaduna. Organic matter was low, total nitrogen was high and available phosphorus was medium in both locations. Calcium (Ca^{2+}) was medium in both locations. Magnesium (Ma^{2+}) was high in Minna and medium in Kaduna. Potassium (K^{+}) was low in both locations. Sodium (Na^{2+}) was high in Minna and medium in Kaduna. Cation Exchange Capacity (CEC) and Exchangeable Acidity were low in both locations Esu (1991).

Table 2, shows the analysis of the organic nutrient sources used in Minna and Kaduna during the 2013 rainy season. The analysis revealed that, poultry droppings contained 1.94%N, 0.85%P and 1.5%K. Cow dung contained 1.54%N, 0.52%P and 1.45%K while Horse dung contained 1.40%N, 0.47%P and 0.9%K.

Days to seedling emergence

The influence of nutrient sources on days to seedling emergence of finger millet in Minna and Kaduna are shown in (Table 3). Nutrient sources was not statistically ($P\leq 0.05$) different on number of days to seedling emergence of finger millet in both locations during the sampling period in the study, respectively.

Days to 50% heading

The influence of nutrient sources on 50%heading of finger millet in Minna and Kaduna are shown in (Table 3). Nutrient sources had a significant ($P\leq 0.05$) effect on days to 50% heading of finger millet. The application of recommended dose of inorganic fertilizer (100 kg N, 50

Table 2. Fadama soils in Katcha Local Government Area Kaduna.

Critical limits for interpreting levels of analytical parameters			
Parameter	**Low**	**Medium**	**High**
Ca^{2+} (cmo $l_{(+)}$ kg^{-1})	< 2	2 – 5	> 5
Mg^{2+} (cmo $l_{(+)}$ kg^{-1})	< 0.3	0.3 – 1	> 1
K^{+} (cmol $_{(+)}$ kg^{-1})	< 0.15	0.15 – 0.3	> 0.3
Na^{2+} (cmol $_{(+)}$ kg^{-1})	< 0.1	0.1 – 0.3	> 0.3
CEC (cmol $_{(+)}$ kg^{-1})	< 6	6 – 12	> 12
Org. C (g kg^{-1})	< 10	10 – 15	> 15
Total N (g kg^{-1})	< 0.1	0.1 – 0.2	> 0.2
Avail. P. (mg kg^{-1})	< 10	10 – 20	> 20
B.S (%)	< 50	30 – 80	> 80

Source: Esu (1991).

Table 3. Nutrient composition analysis of organic nutrient sources.

Organic nutrient sources samples	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Poultry	1.94	0.85	1.5
Cow-dung	1.54	0.52	1.45
Horse dung	1.40	0.47	0.9

Table 4. Influence of nutrient sources on days to 50 % emergence and days to 50 % heading of finger millet in Minna and Kaduna.

Nutrient sources	Rate	Days to seedling emergence		Days to 50% heading	
		Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	9.33a	9.33a	100.00c	203.00b
Poultry dropping	2 t/ha1	9.33a	9.00a	103.00bc	103.00b
Cow dung	4.5 t/ha1	9.67a	9.33a	102.00bc	104.00b
Horse dung	6 t/ha1	9.33a	9.33a	107.00b	108.00b
Control	0 t/ha1	9.33a	9.00a	113.00.a	114.67a
SE±		0.32	0.34	1.53	1.67

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK).

kg P_2O_5 and 50 kg K_2O/ ha) produced shortest days to 50% heading though at a *par* with the application of poultry droppings and cow dung in Minna. All the organic nutrient sources produced similar shortest days to 50% heading in Kaduna, while control produced the longest number of days to 50% heading.

Leaf length

The influence of nutrient sources on leaf length of finger millet in Minna and Kaduna are in (Table 4). Nutrient sources had a significant (P≤ 0.05) effect on leaf length throughout the sampling periods 3, 6 and 9 (WAS) in this study. The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced significantly (P≤ 0.05) longest leaves in both locations, though statistically similar with the application of poultry droppings and cow dung in Kaduna at 3 WAS. The control produced the shortest leaves in both locations throughout the sampling period, respectively.

Plant height

The influence of nutrient sources on plant height of finger millet in Minna and Kaduna are shown in Table 5. Nutrient sources were (P≤ 0.05) different on plant height throughout the sampling periods of 3, 6 and 9 WAS in both locations. The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the tallest plants in both locations, which were at a *par* with the application of poultry droppings at 2 t ha^{-1} only in Kaduna at 3 WAS. The control produced the shortest plants at both locations.

Leaf area

The influence of nutrient sources on leaf area at Minna and Kaduna are shown in (Table 6). Nutrient sources had a significant (P≤ 0.05) effect on leaf area of finger millet at 3, 6 and 9 WAS in both locations and 9 WAS at Kaduna, while reverse was the case at 9 WAS in Minna.

Table 5. Influence of nutrient sources on leaf length of finger millet in Minna and Kaduna.

Nutrient sources	Rate	3 WAS		6 WAS		9 WAS	
		Minna	Kaduna	Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	45.33a	35.83a	56.50a	53.23a	72.37a	64.60a
Poultry dropping	2 t/ha[1]	39.50b	33.73a	46.80b	45.07b	50.60b	55.30b
Cow dung	4.5 t/ha[1]	35.90b	33.33a	39.60c	40.77c	45.47b	47.73c
Horse dung	6 t/ha[1]	33.63b	27.77b	43.57bc	36.87d	45.67b	42.60d
Control	0 t/ha[1]	26.67c	22.00c	33.10d	30.03e	33.80c	35.43e
SE±		1.73	1.17	1.51	0.52	1.2	0.44

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK). WAS – Weeks after sowing.

Table 6. Influence of nutrient sources on plant height of finger millet in Minna and Kaduna.

Nutrient sources	Rate	3 WAS		6 WAS		9 WAS	
		Minna	Kaduna	Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	58.83a	47.77a	78.83a	72.07a	93.83a	92.93a
Poultry dropping	2 t/ha1	48.83b	44.23ab	63.30b	60.53b	77.07b	79.13b
Cow dung	4.5 t/ha[1]	44.63b	41.80b	57.17c	51.52c	67.93c	69.43c
Horse dung	6 t/ha[1]	41.77b	35.30c	55.47c	49.40c	65.87c	61.90d
Control	0 t/ha[1]	34.67c	28.28d	46.43d	42.13d	56.23d	56.87e
SE±		1.78	1.38	1.49	1.68	1.93	0.48

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK). WAS – Weeks after sowing.

Table 7. Influence of nutrient sources on leaf area of finger millet in Minna and Kaduna.

Nutrient sources	Plant height	3 WAS		6 WAS		9 WAS	
	Rate	Minna	Kaduna	Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	50.80a	40.25a	68.73a	61.33a	76.46a	94.50a
Poultry dropping	2 t/ha[1]	42.07b	36.06b	42,80b	47.00b	77.22a	74.38b
Cow dung	4.5 t/ha[1]	35.85c	33.34b	37.53bc	39.377c	62.30a	64.22c
Horse dung	6 t/ha[1]	31.11d	25.71c	34.23c	31.93d	61.18a	53.46d
Control	0 t/ha[1]	24.o4e	19.81d	25.33d	26.57e	41.38a	37.53e
SE±		1.3	0.83	1.77	0.98	12.27	1.94

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK). WAS – Weeks after sowing.

The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the widest leaves while the control produced the smallest leaf area at both locations.

Leaf area index

The influence of nutrient sources on leaf area index of finger millet at 3, 6 and 9 WAS in Minna and Kaduna are shown in (Table 7). Nutrient sources was significantly (P≤ 0.05) different on leaf area index of finger millet throughout the sampling periods. The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the highest leaf area index, while the control produced the lowest leaf area index at both locations.

Internode length

The influence of nutrient sources on internodes length of finger millet at 3, 6 and 9 WAS in Minna and Kaduna are shown in (Table 8). The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the longest internodes which was non-significant difference with the application of poultry droppings at 2 t/ha^{-1} in Kaduna at 9 WAS. The control constantly produced the shortest internodes in both locations though at par with the application of horse dung at 6 t/ha^{-1} in Minna at 9 WAS only.

Finger length

The influence of nutrient sources on finger length of finger millet in Minna and Kaduna are shown in (Table 9). Nutrient sources were (P≤ 0.05) different. The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the longest fingers though at a *par* with the application of poultry droppings at 2 t/ha^{-1} in Kaduna. The control produced the shortest

Table 8. Influence of nutrient sources on leaf area index of finger millet in Minna and Kaduna.

Nutrient sources	Rate	3 WAS		6 WAS		9 WAS	
		Minna	Kaduna	Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	0.034a	0.027a	0.046a	0.041a	0.067a	0.063a
Poultry dropping	2 t/ha[1]	0,028b	0.024b	0.028b	0.031b	0.051b	0.049b
Cow dung	4.5 t/ha[1]	0.024c	0.023b	0.025bc	0.026c	0.042c	0.043c
Horse dung	6 t/ha[1]	0.021c	0.017c	0.023c	0.021d	0.041c	0.035d
Control	0 t/ha[1]	0.016d	0.013d	0.017d	0.018e	0.027d	0.025e
SE±		0.0009	0.0006	0.0012	0.0005	0.0017	0.0015

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK). WAS – Weeks after sowing.

Table 9. Influence of nutrient sources on internodes length of finger millet in Minna and Kaduna.

Nutrient sources	Rate	3 WAS		6 WAS		9 WAS	
		Minna	Kaduna	Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	3.60a	3.43a	4.55a	4.21a	5.78a	5.17a
Poultry dropping	2 t/ha[1]	3.18b	2.97b	3.73b	3.65b	5.11b	5.08a
Cow dung	4.5 t/ha[1]	2.59c	2.58c	3.25c	3.11c	4.41c	3.71b
Horse dung	6 t/ha[1]	2.12d	1.99d	2.90d	2.88d	3.82d	3.66b
Control	0 t/ha[1]	1.83e	1.81e	2.35e	2.42e	3.96d	3.24c
SE±		0.06	0.05	0.03	0.04	0.06	0.07

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK). WAS – Weeks after sowing.

Table 10. Influence of nutrient sources on finger length and number of fingers of finger millet in Minna and Kaduna.

Nutrient sources	Rate	Finger length (cm)		Number of finger	
		3 WAS		6 WAS	
		Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	15.27a	12.40a	12.00a	11.00a
Poultry dropping	2 t/ha[1]	12.27b	11.20b	10.00b	11.00a
Cow dung	4.5 t/ha[1]	8.53c	7.67b	10.00b	9.00b
Horse dung	6 t/ha[1]	8.80c	8.23b	9.00c	8.00c
Control	0 t/ha[1]	8.47c	7.57b	7.00d	6.00d
SE±		0.69	0.63	0.31	0.4

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK). WAS – Weeks after sowing.

fingers though at a *par* with the application of cow dung and horse dung in both locations.

Number of Finger

The influence of nutrient sources on number of fingers of finger millet in Minna and Kaduna are shown in (Table 9). Nutrient sources had a significant (P≤ 0.05) effect on number of fingers at both locations during the sampling period of the study. The application of of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the highest number of fingers which was in turn similar plots that had the application of poultry droppings at 2 t/ha^{-1} in Kaduna. The control produced the lowest number of fingers in both locations during this study.

Number of seeds per head

The influence of nutrient sources on number of seeds per head of finger millet in Minna and Kaduna are shown in Table 10. Nutrient sources had (P≤ 0.05) effect on number of seeds per head of finger millet. The application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the highest number of seeds per head which was followed by plots given poultry droppings at 2 t/ha^{-1} and cow dung at 4.5 t/ha^{-1} which were also statistically similar. The lowest numbers of seeds produced were recorded in the control plots in both locations.

Table 11. Influence of nutrient sources on number of seeds and spike weight of finger millet in Minna and Kaduna.

Nutrient sources	Rate	Number of seed		Spike weight (Kg/ha^{-1})	
		3 WAS		6 WAS	
		Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	4855.00a	4790.00a	11.47a	11.47a
Poultry dropping	2 t/ha^{1}	2877.00b	2742.70b	9.62a	9.62a
Cow dung	4.5 t/ha^{1}	2860.30b	2735.00b	9.62a	9.62a
Horse dung	6 t/ha^{1}	1646.70c	1700.30c	9.07c	9.07a
Control	0 t/ha^{1}	832.3d	785.7d	9.58a	9.58a
SE±		77.44	131.61	0.84	0.84

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK).
WAS – Weeks after sowing.

Table 12. Influence of nutrient sources on grain yield and seed weight of finger millet in Minna and Kaduna.

Nutrient sources	Rate	Grain yield Kg/ha^{-1}		Seed weight (g)	
		Minna	Kaduna	Minna	Kaduna
Inorganic fertilizer (N:P:K)	(100,50,50)	4530.70a	4241.30a	1.84a	1.64d
Poultry dropping	2 t/ha^{1}	3332.70b	3299.00b	2.59a	2.48c
Cow dung	4.5 t/ha^{1}	3083.30c	3033.30b	1.90bc	1.76c
Horse dung	6 t/ha^{1}	2604.30d	2452.70c	1.95b	1.86b
Control	0 t/ha^{1}	2064.70e	1856.30d	1.46d	1.29c
SE±		71.58	96.31	0.02	0.02

Means with the same letter(s) in the same column are not significantly different at P ≤ 0.05 by (SNK).
WAS – Weeks after sowing.

Spike weight

The influence of nutrient sources on spike weight of finger millet in Minna and Kaduna are shown in (Table 10). Nutrient sources was not statistically (P≤ 0.05) different on spike weight of finger millet in both locations respectively.

Grain yield

The influence of nutrient sources on grain yield of finger millet in Minna and Kaduna is shown in (Table 11). Nutrient sources had a significant (P≤ 0.05) effect on grain yield of finger millet, such that the application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) produced the highest grain yield, while the control produced the lowest grain yield in both locations, respectively.

Seed weight

The influence of nutrient sources on seed weight of finger millet in Minna and Kaduna are shown in (Table 11). Nutrient sources had a significant (P≤ 0.05) effect on seed weight of finger millet in both locations. The application of recommended dose of poultry droppings at 2 t/ha^{-1} produced the heaviest seeds, while the control produced the lightest seeds in both locations.

Correlation analysis

The results of correlation analysis between some growth, yield attributes and grain yield of finger millet in Minna and Kaduna in 2013 are shown in (Tables 12) respectively.

In Minna, with the exception of leaf area at 9 WAS, number of days to seedling emergence, spike weight, seed weight that had no significant correlation with grain yield, and number of days to 50% heading that correlated significantly but negatively all the growth and yield attributes measured correlated positively and significantly with grain yield (Table 12). The strongest relationship between a growth attribute and the grain yield in Minna, was that between number of seeds per head and grain yield (r=0.986**), followed by plant height at 9 WAS and grain yield (r=0.964**). Furthermore, the strongest relationship between any two growth parameters recorded, was that between leaf length at 9 WAS and plant height at 9 WAS (r=0.976**), leaf length at 9 WAS and leaf area index at 9 WAS (r=0.968**) in this study.

In Kaduna, with the exception of number of days to seedling emergence, seed weight, spike weight that had no significant correlation with grain yield, and number of days to 50%heading that correlated significantly but negatively, all the growth and yield attributes measured correlated positively and significantly with grain yield. The strongest relationship between a growth attribute and the grain yield in Kaduna was that between leaf area index at 9 WAS and grain yield (r=0.982**), followed by leaf length at 9 WAS and grain yield (r=0.976**). Furthermore, the strongest relationship between any two growth parameters recorded was that between leaf length at 9 WAS and plant height at 9 WAS (r=0.993**), leaf length at 9 WAS and leaf area index at 9 WAS (r=0.987**) in this study.

Discussion

In this study, it was observed that the tallest plants, longest leaves, widest leaves, highest leaf area index, longest internodes, shortest days to 50%heading, longest fingers, highest number of fingers, seeds per head and grain yield was produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha). Application of poultry droppings at 2 t/ha^{-1} also produced similar shortest days to 50% heading, longest leaves at 3 WAS, tallest plants at 3 WAS, longest internodes at 9 WAS, longest fingers and highest number of fingers as the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha). The application of cow dung at 4.5 t/ha^{-1} also produced similar lowest number of days to 50% heading and longest leaves at 3 WAS as the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha), while the control produced the least growth and yield parameters throughout the study.

Effect of nutrient sources

The minimum number of days to 50% heading produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to the availability of nitrogen in soluble form as at when needed by the crop which in turn enhanced the days to heading of the crop. This finding is in conformity with that of Othy (2002) who reported that number of days to 50%heading was shortest with nitrogen application at 100 kg N ha^{-1}. The longest leaves produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to the availability of nitrogen in their readily available forms at the root zone of the crop as at when required which might have enhanced the meristematic activities which translated into the elongation of the leaves.

The tallest plants produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to its ability to supply soluble nitrogen in the soil solution at the early growth stage and during the active growth period of the crop. This might have translated into the production of longer leaves by the treatment which might have enhanced the utilization of the available growth factors, which in turn translated into taller plants.

This finding is in conformity with that of Vijaymahantesh *et al*. (2013) who reported tallest finger millet plants with the application of 100%nitrogen though through the use of urea 46%.

The widest leaves produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to the longest leaves, tallest plants, produced by the treatment which might have enhanced the utilization of solar radiation and in turn led to the production of wider leaves. Kumara *et al*., (2007) reported similar widest leaves with the application of NPK at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) plus farm yard manure at 5 t/ha^{-1}.

The highest leaf area index produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to its ability to produce the tallest plants, longest leaves and widest leaves. Longest leaves and widest leaves are important determinants of leaf area index.

The longest internodes produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) might be an indication of its ability to produce the longest leaves, widest leaves and highest leaf area index which might have enhanced the trapping of sun light which might have also translated into increased internodes length.

The longest fingers and highest number of fingers per head produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to its ability to record the tallest plants, longest leaves, widest leaves, highest leaf area index and longest internodes. These growth parameters are important determinants of yield attributes of finger millet. This finding is in agreement with that of Ahiwale *et al*. (2013) who reported highest number of fingers with the application of (80 kg N, 40 kg P_2O_5 and 00 kg K_2O/ha).

The highest number of seeds produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to the longest fingers and highest number of fingers produced by the treatment. Length of fingers and number of fingers are great determinants of number of seeds of finger millet. This finding is in agreement with that of Ahiwale *et al*., (2013) who reported highest number of seeds due to longest fingers and highest number of fingers though with the application of recommended dose of inorganic fertilizer plus farm yard manure at 5 t/ha.

The highest grain yield produced with the application of recommended dose of inorganic fertilizer at (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) could be attributed to the longest fingers, highest number of fingers and highest number of seeds per head produced by the treatment which in turn translated into enhanced grain yield of the crop. This finding is in agreement with that of Sinha, (2015) who reported similar highest grain yield with the application of 100%nitrogen through inorganic nutrient source. The heaviest seeds produced with the application of poultry droppings at 2 t/ha^{-1} could be attributed to the slow but steadily release of NH_3N during the grain filling which might have in turn enhanced the weight of the seed of the crop in this study. This finding is in conformity with that of Kumara *et al*, 2007 who mention that better growth of finger millet at its early stage of growth due to better use of available nutrients and soil moisture could result in heavy seed weights.

Correlation analysis

The significant and positive correlations recorded between some of this growth and yield attributes in particular; leaf length, inter-node length, plant height, leaf area index, number of fingers, length of fingers, number of fingers per head, seed weight and grain yield suggest that these characters are important yield determinants in finger millet. This finding agreed with that of Bakut, (2005) who observed significant positive correlation between leaf area index, plant height, seed weight and grain yield though in maize.

Conclusion

In the context of this study, it can therefore be concluded that, longer leaves, taller plants, wider leaves, highest leaf area index, longest internodes, shortest number of days to 50%heading, longest fingers, highest number of fingers, highest number of seeds per head, heaviest spike and highest grain yield was produced by the application of recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha). However, the application of poultry droppings at 2 t/ha^{-1} produced the heaviest seeds. Growth and yield characters measured; particularly leaf length, internode length, plant height, leaf area index, number of fingers, length of fingers, number of fingers per head, seed weight correlated positively and significantly to grain yield.

Recommendation

From the findings of this study, farmers in the Southern and Northern Guinea Savanna should be encouraged to grow finger millet with the application of the recommended dose of inorganic fertilizer (100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha) for enhanced grain yield of finger millet.

AUTHORS` DECLARATION

We declare that this study is an original research by our research team and we agree to publish it in the Journal.

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