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Growth and Yield Response of Sunflower (*Helianthus annuus l*) to Spacing and Nitrogen Fertilization in Southern Guinea Savanna Ecological Zone of Nigeria

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ABSTRACT

The experiments were conducted during 2016 and2017 rainy season; to determine the optimal rate of nitrogen fertilizer and adequate plant spacing for production of sunflower in southern guinea savanna agroecology zone of Nigeria. The treatments consisted of planting spacing three (20cm, 30cm, 40), four levels of nitrogen fertilizer (0, 80, 100 and 120 N Kgha^{-1}). A factorial experiment laid in a Randomized Complete Block Design (RCBD) and replicated three times. The results showed that planting at 40cm significantly produced plants with higher number of leaves; the tallest plants (57.86 and 58.21cm) and bigger plants with stem girth of 2.93cm and 2.94cm respectively. The shortest plants (51.82 and 52.34cm) and the smallest stem girths (2.03 and 2.08cm) were recorded on sunflower that were planted on 20cm plant spacing in both years of cropping. Application of 120 N kg ha^{-1} significantly produced sunflower plants with the highest number of leaves (18.76 and 18.83), tallest sunflowers (60.45 and 61.23cm) and biggest stem girth of 3.03 and 3.12cm in both 2016 and 2017 cropping seasons. These results above were at par with the other rates of nitrogen fertilizer application, but higher than the control plots. Sunflower planted at 40cm apart also significantly produced the heaviest head weight per plant of 149.40 and 152.30g; seed weight per head (78.12 and 87. 66 g) and seed yield of 512. 45 and 524.21kg ha^{-1}.Application of 120 N kg ha^{-1} produced the highest seed yield of 561.59 and 549.42 kg ha^{-1} of sunflower in both cropping seasons. This result is statistically at par with application rate of 100 N kg ha^{-1}; which produced 557.41 and 547.06 kg ha^{-1} seed yield of sunflower. This is also the same with application of rate of 80N kg ha^{-1} which produced 528.87 and 525. 10kg ha^{-1} seed yield of sunflower in both cropping seasons respectively. The control plots produced the lowest seed yield (312.89 and 322.23 kg ha^{-1}) in both years of cropping. It can be concluded that 80 N kg ha^{-1} is the optimal nitrogen requirement and planting at 75cm X 40cm apart is adequate plant spacing for production of sunflower in southern guinea savanna agroecology zone of Nigeria.

KEYWORDS: *Fertilizer, Growth, Nitrogen, Spacing, Sunflower, Yield*

INTRODUCTION

Sunflower (*Helianthus annuus L.)* is an annual erect broadleaf oil crop with a strong tap root system. It is one of the few crops that originated from North America, but the leading countries of production of sunflower are: Russia, Argentina, Eastern Europe, US, China, France and Spain (Smith, 1995). Apart from sunflower being a good oil crop it can also be a good source of snack seeds as well as animal feeds. The crop is suited to wide range of agro ecological zones with wide range of temperatures, soil types and rainfall patterns. It ranks the third most important source of edible oil in the world after soya bean and cotton (Ahmad et al., 2011). Sunflower (*Helianthus Annuus)* is a tolerant annual crop that grows extensively in all the nooks and crannies of Nigeria under wild uncoordinated conditions; but widely uncultivated by Nigerian farmers. However, large fields of hybrid sunflower farms are a common sight in Ghana, Cote d'Ivoire and Mali in the West African sub region and also South Africa where it is widely cultivated. Many sunflower growers believe that sunflower do not require application of fertilizer as much as cereals. However, nutrients play important role in the growth and development of sunflower. Nutrient management is one of the most critical factors affecting seed yield in sunflower. Among the different nutrients, nitrogen is one of the major nutrients that enhance the metabolic processes, which leads to increases in vegetative, reproductive growth and yield of the crop (Koutroubas et al., 2008). Additionally, higher rates of N increases photosynthetic processes, leaf area production, leaf area duration as well as net assimilation rate (Ahmad et al., 2009; Munir et al., 2007). Plant spacing is among the factors affecting sunflower yield and seed oil percentage. The wide plant spacing enhanced stem diameter, head diameter and seed weight per head, while plant height and seed and oil yields fed^{-1} were increased with narrow plant spacing (Allam et al., 2003).Earlier research works on sunflower agronomy in the tropics reported varying optimum rates of nitrogen fertilizer to be 80 kgNha^{-1} in India (Rasool et al., 2013); 150kg N ha^{-1} at Islamabad, Pakistan (Bakht et al.,

200).In Nigeria, (Olowe et al., 2005) Earlier reported 60 kg Nha^{-1}in a forest Savanna transition zone of south west Nigeria; (Oyinlola et al., 2010) reported 90- 100 kg N ha^{-1}on an Alfisol of the Northern Guinea savanna of Nigeria was suitable for sunflower and the higher rate (150 kg N ha^{-1}) indicates a negative effect on the oil contents and yield. Also (Wabekwa et al., 2015), recommended the application of 60 kg N ha^{-1} for sunflower in Sudan-Northern Guinea Savanna agro-ecological zone of Nigeria. On the other hand, there is dearth of documented information on nitrogen requirement of sunflower in southern guinea savanna agroecological of Nigeria. Therefore, the objective of this study is to determine the optimal rate of nitrogen fertilizer and adequate plant spacing for production of sunflower in southern guinea savanna agroecology zone of Nigeria.

MATERIAL AND METHODS

The Experimental Site

The experiments were conducted during 2016 and2017 rainy season at the research and teaching farm of the college of agriculture, Lafia, Nasarawa state, Nigeria. The study area falls within southern guinea savanna agroecological zone of Nigeria, and is located between Latitude08.33 N and Longitude 08.32 E.

Climate Conditions

Rainfall usually starts from May – October and the average monthly rainfall figures ranges from 40 mm-350mm. The months of July and August usually records heavy rainfall. The daily maximum temperature ranges from 20.0ºC – 38.5ºC and daily minimum ranges from 18.7ºC – 28.2ºC. The relative humidity rises as from April to a maximum of about 75- 90 percent in July (NIMET, 2017).

Soil and Vegetation Conditions

The soil type of the study area composed of highly leached Alfisols with low base saturation. The soil is strongly acidic and has high content of iron and Aluminum oxides hence reddish brown in colour with very low organic matter content and low total nitrogen and available phosphate. The vegetation of the study area is that of the southern Guinea Savanna with interspersion of thicket, grassland, trees, fringing woodlands or gallery forest along the streams. The natural vegetation of the area is made up of grasses and some traces of scattered wild and economic trees like *Vittellaria paradoxa*(Shear butter tree);*Parkia* spp (locust bean tree); *Gmelina* arborea(beechwood); *Anacadium* spp (Cashew trees);*Magnifera indica*(Mango). These trees usually shed off their leaves in the long dry season to conserve the available water.

Experimental Design and Data Collection

The treatments consisted of planting spacing (75 X 20CM, 75 X 30CM, 75 X 40CM), four levels of nitrogen fertilizer (0, 80, 100 and 120 $NKgha^{-1}$). A factorial experiment, laid in a Randomized Complete Block Design (RCBD) and replicated three times to form thirty six plots. The plot size was 3 m by 4 m plots and 0.5 m between plots. The soil data for this study were collected from soil samples at the depth of 15 cm from experimental plots before planting for analysis. The land was cleared, ploughed and harrowed. Sunflower seeds were obtained from I.A.R (ABU Zaria) and the urea fertilizer was purchased from Nasarawa state agricultural development program (N.A.D.P). Weeds were control by hand hoeing and insect pest were controlled using sprayed with karate 5EC. The following parameters [% Seedling emergence, plant height, stem girth, number of leaves, days to first flowering, days to maturity, head weight, head diameter, seed weight per head and seed weight per hectare] were assessed in both years.

Data analysis

The data collected were subjected to analysis of variance using GENSTAT, and where there is a significant difference; the means were separated using F-LSD at 5% probability level

RESULTS

Soil and Manure Analysis

The soil of the experimental site was low in most of the plant nutrient elements (Table 1). The soil was very low in nitrogen, phosphorus, potassium, organic carbon and the same with cation exchange capacity. Also, the soil was slightly acidic in nature (6.08, 6.10); high in percent sand fraction (85.00, 84.00) and also very high in base saturation (87.00, 90.39) in both 2016 and 2017 cropping seasons.

Properties	2016	2017
Mech. Composition		
Clay (%)	11.6	12.6
Silt (%)	3.4	3.4
Sand (%)	85.0	84.0
TCL (USD)	SL	SL
Chemical composition		
pH(H2O)	6.08	6.10
pH(0.01MKCl2)	6.00	5.44
T N%	0.04	0.07
% OC	0.64	0.86
% O M	1.10	1.48
Avail. P(ppm)	4.57	12.29
K($mgkg^{-1}$)	0.31	0.38
Mg($cmolkg^{-1}$)	1.78	1.28
Ca($cmolkg^{-1}$)	3.41	4.83
Na($cmolkg^{-1}$)	0.67	0.42
Al + H(acidity)	0.83	0.76
CEC($cmolkg^{-1}$)	6.17	7.91
%Base Saturation	87.00	90.39

Table 1: Laboratory analysis of soils at 0-30cm before cropping in both years

Plant spacing showed a significant increase in number of leaves, plant height and stem girth of sunflower plant (Table2) in both years of cropping. Planting at 75 X 40cm significantly produced the tallest plants (57.86cm and 58.21cm) and bigger plants with stem girth of 2.93cm and 2.94cm respectively. Number of leaves, plant heights and stem girths were statistically the same with the sunflower that were planted 30cm a part. The shortest plants (51.82cm and 52.34cm) and the smallest stem girths (2.03cm and 2.08cm) were recorded on sunflower that were planted on 20cm plant spacing in both years of cropping. Also, nitrogen fertilizer had a significant increase on all the vegetative parameters (number of leaves, plant height and stem girth) assessed in both years of cropping. Application of $120kgha^{-1}$ of nitrogen fertilizer tend to produced sunflower plants with the highest number of leaves (18.76 and 18.83), tallest sunflowers (60.45cm and 61.23cm) and biggest stem girth of 3.03cm and 3.12cm in both 2016 and 2017 cropping seasons. These results above were at par with the other rates of nitrogen fertilizer application, but higher than the control plots.

Table 2: effect of plant spacing and Nitrogen rates on the growth parameters of sunflower at seven weeks after planting

Treatment	Number of leaves		Plant height (cm)		Stem girth(cm)	
	2016	2017	2016	2017	2016	2017
Spacing(cm)						
20	17.08	17.11	51.82	52.34	2.03	2.08
30	17.22	17.24	52.34	53.32	2.54	2.56
40	17.50	17.53	57.86	58.21	2.93	2.94
LSD(0.05)	0.29	0.32	3.24	3.82	0.75	0.54
Nitrogen(kgha^{-1})						
0	15.33	14.98	40.21	42.65	2.29	2.32
80	17.00	17.97	57.35	56.69	2.96	2.98
100	17.98	17.78	58.24	58.26	3.01	3.05
120	18.76	18.83	60.45	61.23	3.03	3.12
LSD(0.05)	1.26	1.56	4.45	5.54	0.42	0.52

Plant spacing had a significant increased on head weight per plant, seed weight per head and seed yield kgha^{-1} (Table 3) in both cropping seasons. Sunflower planted at 40cm apart produced the heaviest head weight per plant of 149.40 and 152.30g; seed weight per head (78.12 and 87. 66 g) and seed yield kg ha^{-1} of 512. 45 and 524.21kg ha^{-1}.Nitrogen fertilizer rates also had a significant response on head diameter, head weight per plant, seed weight per head and seed yield kgha^{-1}of sunflower in both 2016 and 2017 cropping seasons. Application of 120 kg ha^{-1} of nitrogen fertilizer produced the highest seed yield of 561.59 and 549.42 kg ha^{-1} $_{of}$ sunflower in both cropping seasons respectively. This result is statistically at par with application rate of 100 N kg ha^{-1}; which produced 557.41 and 547.06 kg ha^{-1} seed yield of sunflower. This is also the same with application of rate of 0N kg ha^{-1} which produced 528.87 and 525. 10kg ha^{-1} seed yield of sunflower in both cropping seasons respectively. The control plots produced the lowest seed yield (312.89 and 322.23 kg ha^{-1}) in both years of cropping respectively.

Table 3: effect of plant spacing and Nitrogen rates on yield parameters of sunflower

Treatment	Days to 1st flower		Days to maturity		Head diameter (cm)		Headwt/plant (g)		Seedwt/head (g)		Seed yield(kg/ha)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Spacing(cm)												
20	48.23	47.42	86.98	86.58	7.24	7.17	132.43	128.65	64.45	68.96	446.46	458.12
30	48.12	47.08	86.54	86.00	7.32	7.34	145.58	149.21	76.05	84.38	479.23	484.63
40	48.01	47.08	86.67	85.25	7.12	8.07	149.40	152.30	78.12	87.66	512.45	524.21
LSD(0.05)	0.54ns	0.65NS	0.85ns	1.75ns	1.34ns	1.54NS	31.45	28.23	2.21	2.71	21.34	20.56
Nitrogen(kgha^{-1})												
0	47.54	46.78	85.81	85.33	6.21	6.14	122.34	120.02	22.34	23.37	312.89	322.23
80	48.12	47.00	86.12	85.89	7.10	7.29	147.42	141.82	26.87	27.59	528.87	525.10
100	48.18	47.44	86.54	86.11	7.98	8.01	159.23	150.00	27.58	27.72	557.41	547.06
120	48.21	47.56	86.97	86.44	8.15	8.03	161.34	150.00	28.32	27.98	561.59	549.42
LSD(0.05)	1.79ns	1.54NS	0.45	0.87	1.21	1.56	20.12	25.54	3.21	3.13	98.57	100.32

DISCUSSION

Increased in plant spacing had a significant response to growth and yield of sunflower; and this may be as a result of reduction in plant density or plant population per unit area. Plant spacing of 75cm X 40cm, which means fewer plant densities per unit area produced vigorously growing sunflower plants that were better than other narrow spaced plants. This may be due to the presence of more supply of nutrient, light, moisture, air and less competition of these growth factors because of fewer numbers of sunflower plants as compared to narrow spacing. This finding corroborates the result obtained by (Mahmood, 2013). However, a contrary result was earlier reported by (Ibrahim, 2012), who was working on the response of some sunflower hybrids to different levels of plant density; and revealed that increasing plant density led to significant increases in plant height, leaf area index, total dry matter production per ha and seed yield per ha were recorded. He explained his findings on the basis where competition between plants for growth is expected to increase with increasing plant densities. That would lead to taller plants due to competition for light and earlier flowering due to competition for nutritional resources. However, he concluded that the collective influence of higher plant densities will also lead to higher production per hectare. The significant response of growth parameters of sunflower to application of different rates of nitrogen could be attributed to the poor nutrients nature of the soil especially nitrogen (Table 1). Therefore, the amount of nitrogen applied was sufficient to correct the initial nitrogen deficiency in the soil; which resulted to vigorous vegetative growth of sunflower when corresponding increase in nitrogen fertilizer was applied (Olowe et al., 2005). This is due to the fact that adequate supply of N is associated with formation of more protoplasm, more succulent plant growth, high photosynthetic activity, vigorous growth and dark green color of leaves (Ndor et al., 2008).The total number of seeds perhead was significantly increased by nitrogen application. This effect is possibly due to the increase in head diameter resulting from nitrogen application. These results are in accordance with (Oyinlola et al., 2010); who worked on the response of sunflower to nitrogen application in the savanna alfisols. (Ali et al., 2014), documented a contrary results that, the application of 40 kg N ha^{-1} and 80 kg N ha^{-1} significantly reduced the final seeds yield in comparison to control.

CONCLUSSION

In conclusion, the study revealed that plant spacing of 75 X 40cm is recommended to be the best plant spacing for cultivation of sunflower and 80 Kg N ha-1 is the optimal nitrogen rate, that is require for cultivation of sunflower in the southern guinea savanna agro ecological zone of Nigeria.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. Author EN designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author HA managed the analyses of the study, performed the spectroscopy analysis and IUN managed the experimental process, literature searches and identified the species of plant. All authors read and approved the final manuscript

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