EFFECT OF INTRA-ROW SPACING AND NITROGEN RATES ON GROWTH AND YIELD OF SWEET SORGHUM (*Sorghum bicolor L.*) Var. 64DTN

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ABSTRACT

Two Field trials were conducted in 2015 and 2017 rainy seasons in the Research Farm of the National Agricultural Extension and Research Liaison Service; Ahmadu Bello University (NAERLS/ABU) North Central Zone, Badeggi (9°45'N and 7°31'E) within the Southern Guinea Savannah to test the effect of intra-row spacing and nitrogen rates on growth and yield of Sweet Sorghum (Sorghum bicolor L.) Var.64DTN. The treatment was made up of three intra-row spacing (30, 50 and 70cm) combined with four nitrogen rates (0, 60, 90 and 120kg N/ha). Split plot design was used for the experiment and replicated three times The results have shown that intra-row spacing had a significant influence on plant height, total dry matter, number of leaves per plant and grain yield but had no effect on stand count. Neither intra-row spacing nor nitrogen had an effect on panicle length. Nitrogen application was also observed to have significant influence on all the characters mentioned earlier. The closet intra-row spacing of 30cm gave 41.07% and 45.71% increase in yield in 2015 and 2017 respectively over the widest spacing of 70cm. the response of Sweet Sorghum yield to nitrogen was up to 90 and 120kg N/ha in 2015 and 2017 respectively. The increase in yield when these responses were compared to plot that did not receive nitrogen was 33.15% and 19.37% for 2015 and 2017 respectively.

***Keywords:** Nitrogen, Intra-row spacing, Sweet Sorghum Var.64DTN-*

INTRODUCTION

Sorghum (*Sorghum bicolor L.*) commonly referred to as Guinea Corn in West Africa. Sweet Sorghum is similar to grain sorghum except for its juice rich sugary stalks that grow rapidly, yielding higher biomass. Sweet sorghum consist of approximately 75% cane, 10% leaves, 5% seeds and 10% roots by weight (Grassi *et al*; 2002). The crop like the grain sorghum produces grain which can be harvested for human consumption and accumulates sweet juice in its stalk which can be extracted and processed to syrup or fermented to produce ethanol. The materials remaining after the extraction for the juice called bagasse used as animal feed. The starch from the grains may also be fermented to produce ethanol (Mutepe *et al.*, 2012). It is a bioenergy crop which accumulate large amount of fermentable sugar in its stalk in a similar way to sugarcane. It is grown mainly for syrup production in USA especially on small scale and for bioethanol production in India and elsewhere (Rao *et al.*, 2009, and Itan *et al.*, 2012). Its rationing ability enable multiple harvests per season, a feature that could expand the geographical range of Sorghum cultivation (Rao *et al.*, 2013). Egharevba (1979) reported the use of sorghum in local recipes like Tuwo, Akamu and Kunu in Nigeria. Even though sorghum adapt to wide ecological conditions the yield still remains low under the traditional farming practice.

Several workers suggested improved management practices in order to increase the yield of sorghum. This include using optimum plant population Dogger (1970), mineral nutrition especially nitrogen. Abubakar *et al.*. (2012) reported that nitrogen increase the plumpness of cereal grain and their percentage protein and also aid the utilization of Potassium and Phosphorus. Sorghum was observed to respond to applied nitrogen and the additional fertilizer was necessary for optimum yield. Nitrogen was reported to increase plant height, leaf area index, crop growth rate, relative growth rate and dry weight per plant, Net assimilation rate NAR, CGR, RGR and AGR Abayomi. (2014).

The grain yield of Sorghum was also observed to increase with increase in Nitrogen up to 120kg N/ha Jaliya *et al.* (2013). However, Mani (2004) reported yield response of improved sorghum up 150kg N/ha. Intra-row spacing was reported to affect the growth and yield of sorghum and it varies with cultivars, soil fertility and the amount and duration of rainfall Filho *et al.* (2012). Filho *et al*, (2012) reported decrease in sorghum plant height with decrease in intra-row spacing 70 – 25cm, while Garg and Kayode (2003) reported that wider spacing increased the thickness of the stem. Sorghum grain yield was reported to increase using 30cm intra-row spacing (Harris *et al.*, 2013).

Egharevba (2011) observed that adopting 75-80cm X 35cm in the Southern and Northern Guinea Savannah Zones of Nigeria, resulted in profuse tillering which is not beneficial to ultimate yield of sorghum. In view of the response of sorghum to nitrogen fertilization and plant population especially the improved varieties this experiment was conceived to determine the best intra-row spacing and optimum N rate for maximum growth and yield of Sweet Sorghum variety (64 DTN).

MATERIALS AND METHODS

Experiments were conducted in 2015 and 2017 rainy season at the Research Farm of the National Agricultural Extension and Research Liaison Service, Ahmadu Bello University, Zaria (NAERLS/ABU) North Central Zone, Badeggi (9°45'N and 7°31'E) within the Southern Guinea Savannah ecological Zone of Nigeria. The treatments consisted of three intra-row spacing (30, 50 and 70cm) combined with four nitrogen levels (0, 60, 90 and 120kg N/ha). Split plot design was used with three replications.

The variety 64 DTN obtained from the Institute of Agricultural Research, Ahmadu Bello University Zaria (IAR/ABU) was used as a test crop. The land was prepared by harrowing and ridgesof 75cm apart were made. The gross and net plots were 17.95 and 15.7m respectively. Seeds were sown at intra-row spacing dictated by the treatment combinations. Thinning to one, two and three plants per stand was done for the 30, 50 and 70cm intra-row spacing, respectively. This was done to maintain uniform plant population per hectare. Weeds were controlled at 3 and 8 weeks after sowing (WAS) using hoe. Soil samples were collected from the field at 0-30cm depth and analysed for physio-chemcial properties using standard procedures. The soil was a sandy loam with low pH, low organic carbon, low total nitrogen and low exchangeable bases.

The first dose of nitrogen and basal phosphorus and potassium were applied in form of NPK 15:15:15 by side dressing. Phosphorus and potassium were applied at 30kg each of P_2O_5 and K_2O. The second dose of nitrogen was applied using Urea (46%N) to supply the balance of nitrogen as dictated by the treatment combinations. Data on stand count, plant height, number of leaves per plant, dry matter per plant, flag leaf area, panicle length and yield were collected and analysed using the general linear model in SAS (SAS, 1989) as described by Snedecor and Cochran (1967). The means were separated using Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Effect of Intra-row spacing and yield of sorghum

The results of the soil analysis varied as shown in Table 1. The soil chemical properties was generally low in organic carbon and total nitrogen. The electrical conductivity (EC) value of the soil (0.08 and 0.9ds/m^2) indicated that the soil were not salt affected. From the result (Table 1), the soil textural class at the experimental site was sandy loam. The soil was slightly acid tending to alkaline (5.40 to 6.0) condition in water indicating moderate soil condition for sorghum production (kamprath, 2009).

Intra-row spacing had no effect on stand count in both years (Table 2). Plant height was significantly affected by intra-row spacing in 2015 and 2017, and 50cm intra-row spacing was observed to give significantly higher plant height than 70cm spacing which was in turn significantly higher than 30cm intra-row spacing in both years (Table 2). During the 2015 cropping 30cm intra-row spacing gave significantly higher number of leaves per plant than 50 and 70cm intra-row spacing which were statistically similar, however, in 2017 the trend was reversed with 50 and 70cm spacing being at par with one another but significantly higher than 30cm intra-row spacing. Widely spaced plants might have had more environmental resources for growth hence more leaves per plant than the closely spaced plants. This is especially true for sorghum that is a heavy feeder with high light requirement as observed by Evans, (2013).

The dry matter per plant was significantly affected in 2015 only. The closest intra-row spacing (30cm) produced statistically higher dry matter per plant than 50 and 70cm spacing. This trend could be due to the effect of less competition under this spacing, especially under optimum fertilizer condition as indicated on the number of leaves per plant. In the same year, 2015, there were more leaves per plant under 30cm spacing, which provided more photosynthetic surface for assimilate production and translocation, thus affecting subsequent dry matter production. This conforms to the findings of Mani *et al.* (2007), who reported maximum dry matter production with closer spacing under heavy fertilization. The flag leaves area and panicle length were not affected significantly by intra-row spacing. The grain yield of sorghum was influenced significantly in both years with 30cm intra-row spacing which were at par with one statistically. The increase in yield might be due to better light utilization by the closely spaced plants, hence higher dry matter for grain filling. The observation is similar to that of Ishaq and Babekir (2011).

Effect of Nitrogen on Growth and Yield of Sorghum

Sorghum stand count was significantly influenced by nitrogen application in 2015 and it was observed that 60, 90 and 120kg N/ha produced significantly higher stand count than the control plot (Table 2.) Nitrogen application supported the growth and survival of the emerging seedling through its effect on cell division, elongation and tissue differentiation.

Plant height was significantly affected by nitrogen application in both years. In 2015 application of 120kg N/ha gave significantly taller plants than all the other Nitrogen rates though at par with 60kg N/ha which was in turn statistically similar to 90kg N/ha. In 2017 trial, plant that had 90 and 120kg N/ha were statistically similar in height but produced significantly taller plants than 60kg N/ha and the control. Increase in height due to nitrogen application was reported by Abubakar *et al.* (2012).

The number of leaves per plant was significantly affected by nitrogen application in both years. The trend in the two years was similar with plants that received 90 and 120kg N/ha being similar statistically in terms of number of leaves per plant but produced significantly more leaves per plant than plants that received 60kg N/ha which was in turn significantly higher than the control. The flag leaf area and panicle length were not significantly influenced by nitrogen. However, Abayomi (2014) reported increase in Leaf Area Index with application of 90kg N/ha in Sorghum. Nitrogen application of 90kg N/ha was equally observed to increase dry matter production in sorghum. The control plots that did not receive nitrogen produced significantly lower dry matter per plant than all nitrogen rates tested, though statistically at par with 60kg N/ha in 2015 and 2017. There was also no significance between 60 and 90kg N/ha as well as between 90 and 120kg N/ha, with respect to dry matter production per plant in all the trials. The increase in dry matter could be due to increase in number of leaves available for assimilate production and translocation and storage.

The grain yield was significantly increased by nitrogen application up to 90kg N/ha in 2015 and 120kg N/ha in 2017 (Table 2). The yield could be as a result of good dry matter production for grain filling as a result of higher number of leaves. Increase in yield of sorghum due to nitrogen application has been reported by some workers (Galbiatti *et al*, 2011, Obilana 1983).

Intra-Row Spacing and Nitrogen Interaction on Growth and Yield of Sorghum

Significant interaction between intra-row spacing and nitrogen was observed at 120kg in 2015 trial only. Application of 90kg N/ha and 30cm intra-row spacing gave significantly higher plant height than all other treatments combinations except 120kg N/ha and 30cm intra-row spacing (Table 3). Significant interaction was also observed on Sorghum grain yield in 2015 trial and the highest grain yield was obtained with application of either 90 or 120kg N/ha and 30cm intra-row spacing (Table 4). The yield increase with higher nitrogen rates at closer spacing could be due to maximum dry matter production for grain filling that was made possible as a result of taller plants that trapped most of the photosynthetically active radiation, more number of leaves per plant that provided more surfaces for photosynthesis and assimilate production. This result agreed with that of Tatero and Ojima (1993).

Considering the main effect and the interaction, closer spacing seems to favour the growth and yield of sorghum. On the other hand 90kg N/ha was found to be adequate for good growth and yield of sorghum at Badeggi. The interaction effect have shown that 30cm intra-row spacing and 90kg N/ha gave a higher yield that was comparable to 30cm and 120kg N/ha combination. For economic reason 30cm intra-row spacing and 90kg N/ha could be recommended for sorghum production in Badeggi, Niger State.

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Table 1: Physico-chemical properties of Soils from 0-30cm at Experimental Site Badeggi During 2015 and 2017 Rainy Season.

Soil Properties	2015	2017
Properties Size (g/kg)		
Clay	130	110
Silt	150	140
Sand	720	750
Chemical Properties	Sandy-Loam	Sandy Loam
P^H (H_2O; 1:2:5 w/v)	5.40	6.10
P^H (0.01M $CaCl_2$; 2.5 w/v)	6.20	6.60
Exchange Acidity (Cmol/kg soil)	0.05	0.06
Electrical Conductivity (mg/kg)	0.08	0.09
Bray/P (mg/k)	6.40	7.55
Organic Carbon (g/kg)	4.10	5.70
Total N (g/kg)	0.18	0.31
Exchangeable Cations (Cmol/kg)		
K (Cmol/kg)	0.17	0.25
Ca (Cmol/kg)	4.15	5.25
Mg (Cmol/kg)	0.45	0.91
Na (Cmol/kg)	0.23	0.29
CEC K (Cmol/kg)	5.65	6.75
Extract Micro Nutrients (Cmol/kg)		
Zinc (Zn)	6.15	6.55
Sodium Adsorption Ratio (SAR)	0.05	0.07
Percent Base Saturation (PBS)	84.20	88.60

Source: Soil samples as analysed at the Soil Department, Federal University of Technology (FUT), Minna, Niger State, Nigeria.

Table 2: Effect of Intra-row spacing and Nitrogen Rates on Growth and Yield of Sorghum 2015 and 2017 Rainy Season at Badeggi.

Treatments	Stand Count		Plant Height (cm)		Number of Leaves/Plant 12 WAS		Dry Matter/Plant		Flag Leaf Area (cm^2)		Panicle Length (cm)		Grain Yield (kg/ha)	
Intra-row spacing (cm)	2015	2017	2015	2017	2015	2017	2015	2017	2015	2017	2015	2017	2015	2017
30	11.0	13.0	73.06^c	74.31^c	12.38^a	13.11^b	26.00^a	26.11	186.3	183.1	24.1	23.7	1439.78^a	153.10^a
50	10.0	12.0	90.88^a	89.91^a	11.10^b	14.21^a	17.77^b	19.80	177.4	163.7	22.2	23.1	1098.28^b	1171.71^b
70	10.0	13.0	78.06^b	83.31^b	11.29^b	14.78^a	16.73^b	23.40	162.9	142.3	22.4	22.7	10.65.96^b	1106.87^b
SE±	0.83	0.91	0.82	0.83	0.31	0.40	2.56	2.60	1.83	1.94	1.31	0.98	49.86	49.97
Nitrogen kg/ha														
0	8.0^b	11.7	56.86^c	8.86^c	9.01^c	8.53^c	19.31^c	7.40^d	188.7	172.5	20.7	21.3	472.40^d	572.31^d
60	11.0^a	12.0	74.53^{ab}	77.46^b	10.30^b	11.21^b	19.80^{bc}	21.71^{bc}	197.3	184.5	25.7	24.7	602.86^c	877.37^c
90	10.0^{ab}	13.4	72.72^b	80.31^a	12.20^a	13.41^a	26.98^{ab}	29.32^{ab}	183.5	173.3	23.0	21.0	1814.12^a	1913.70^b
120	11.0^a	13.0	75.79^a	80.71^a	11.30^a	12.71^a	28.54^a	31.10^a	174.0	174.0	21.3	20.4.	1517.63^b	2117.70^a
SE±	0.83	0.922	0.82	0.83	0.31	0.40	2.56	2.60	1.83	1.83	1.31	0.98	49.8	49.97
Spacing x Nitrogen interaction	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed with the same letter(s) within a column are not significantly different at 5% level of significance using Duncans Multiple Range Test (DMRT).

Table 3: Intra-Row Spacing and Nitrogen Rates Interaction on Plant Height (cm) of Sorghum at 12 WAS at Badeggi.

Treatments	Intra-Row Spacing (cm)		
Nitrogen (kg N/ha)	30	50	70
0	46.25^{f}	55.92^{e}	39.67^{g}
60	75.25^{c}	74.08^{cd}	66.58^{e}
90	86.67^{a}	75.67^{bc}	68.42^{de}
120	81.75^{ab}	65.08^{e}	66.92^{e}
SE±			

Means followed with same letter(s) within a column or row are not significantly different at 5% level of significance using DMRT.

Table 4: Intra-Row spacing and Nitrogen rates interaction on grain yield (kg/ha) of sorgum at Badeggi.

Treatments	Intra-Row Spacing (cm)		
Nitrogen (kg N/ha)	30	50	70
0	482.3^{f}	417.4^{a}	381.3^{g}
60	879.8^{e}	783.7^{e}	571.7^{fg}
90	1287.7^{ab}	1007.3^{cd}	988.7^{d}
120	1374.3^{a}	1234.3^{b}	1097.7^{c}
SE±			

Means followed with same letter(s) within a column or row are not sign ificantly different at 5% level of significance using DMRT.