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Growth And Yield of Sorghum (*Sorghum bicolor* (L.) Moench) Varities in Sokoto Sudan Savanna of Nigeria

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ABSTRACT: Field trial was carried out during the 2019 rainy season (June to October) at the Dryland Teaching and Research Farm of the Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto to determine the growth and yield of sorghum varieties in the study area. The treatments consisted of five (5) sorghum varieties (Samsorg 45, Samsorg 46, Janjari, Yartawa and Jardawa), the treatments were laid out in a Randomized Complete Block Design (RCBD) replicated three (3) times. Data were collected on the growth and yield of the crop. Janjari and Jardawa varieties were higher in plant height. Jardawa and Yartawa varieties were higher in number of leaves. Janjari and Yartawa varieties were higher in total dry weight. Janjari, Jardawa and Yartawa varieties were higher in harvest index. Yartawa variety was higher in leaf area, leaf area index and 1000-grain weight. Jardawa variety was higher in panicle length. Janjari variety was early in number of days to heading, flowering, and maturity and was higher in dry stalk weight. The grain yield (249 – 1506kg ha^{-1}) was higher in Janjari and Yartawa varieties (1268 – 1506 kg ha^{-1}). Based on the findings of this research, it could be concluded that Janjari and Yartawa varieties performed better than other varieties in the study area.

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Sorghum (*Sorghum bicolor* (L.) Moench) belongs to the family *Poaceae*. The crop originated in Africa and is the fifth largest and most important cereal crop in the world after wheat, maize, rice and barley (Ejeta and Grenier, 2005). In Asia and Africa, sorghum grain is consumed by human or as animal feed, stalks are used as animal fodder or as housing material (Doggett, 1988). Sorghum grain has a high nutritive value, with 70 – 80% carbohydrate, 11-13% protein, 2-5% fat, 1-3% fiber and 1-2% ash (Dicko *et al.*, 2006). The biofuel industry produces ethanol from the sugars accumulated in the stalks of sweet sorghum varieties and from the starch in the seeds of grain sorghum (Almodares and Hadi 2009). Despite this Nigeria yield is low (1192 kg ha^{-1}) compared to Ethiopia (2617 kg ha^{-1}) and the world (1461 kg ha^{-1}) (FAOSTAT, 2017). Sorghum will continue to play a key role in providing food security in Nigeria and Africa, as a whole. Thus, the research was undertaken to provide information on the growth and yield of sorghum varieties in the study area and identify a suitable variety for the study area.

MATERIALS AND METHODS

Experimental Site: Field experiment was carried out in the 2019 rainy season, at the Dryland Teaching and Research Farm of the Faculty of Agriculure, Usmanu Danfodiyo University Sokoto. Sokoto State is located in the north-western Nigeria on latitude $13^{0}01$ North and Longitude 5^{0} 15 East. Sokoto falls under Sudan savanna agro-ecological zone of Nigeria. The climate of the area is semi-arid with mean annual rainfall ranging from 380m- 829mm (SERC, 2012). The area is characterized by erratic rainfall. The maximum and minimum temperatures of the area ranges from 15^{0}C to 40^{0}C, respectively (Singh *et al.*, 2011).

Treatments and Experimental Design: The treatments consisted of five sorghum varieties (Samsorg 45, Samsorg 46, Janjari, Yartawa and Jardawa). Samsorg 45 and Samsorg 46 were improved varieties obtained from Sokoto State Agriculture Development Project (SADP) and the other three (Janjari, Yartawa and Jardawa) were local varieties obtained from the local communities around the university area. The

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treatments were laid out in a Randomized Complete Block Design (RCBD) replicated three times.

Cultural Practices: The experimental site was ploughed and ridged at the onset of the rainy season to make the field free of any vegetation or weeds. The seeds of the varieties were dressed before sowing using Apron Star(R) 42% WS (Mefenoxam 20%, Difenonazole 2% and Thiamethoxam 20%). A pinch of 5-7 seeds was sown, at a depth of 2-3 cm and a spacing of 75 cm × 30 cm. Nitrogen (N), Phosphorus (P_2O_5) and Potassium K_2O fertilizers were applied using a recommended rate of 60kg of N/ha, 30 kg of P_2O_5/ha and 30kg of K_2O/ha. 30kg/ha each of NPK were applied at sowing. The remaining N (30kg) was applied at 6 weeks after sowing. Weeds were manually controlled using hoe at 3 and 6 weeks after sowing. Harvesting was carried out when the panicles attained physiological maturity (a black spot layer appears on the hilum at the base of the seed). The panicles were threshed manually after drying, and the grains were weighed using weighing balance.

Data Collection and Analysis: Data were collected on plant height, number of leaves per plant, leaf area, leaf area index, number of days to flowering, number of days to heading, days to maturity, panicle length, grain weight, dry stalk weight, total dry weight, harvest index and 1000-grain weight. Leaf area was measured using the procedure of (Shih *et al.,* 1981).

$$LA = 0.741\ x\ LW$$

Where L= length, W=width

Leaf area index (LAI) which is the ratio of the leaf area to the ground area occupied by the plant and was measured by dividing the leaf area obtained by the spacing allocated to the plant.

$$LAI = \frac{TLA}{GAO}$$

Where TLA = Total Leaf Area per Plant and GAO = Ground Area Occupied by the plant

The number of days to 50% flowering, heading and maturity was recorded for each plot, a treatment is considered at 50% flowering, 50%heading and 50% maturity when half of the stands within the net plot area have at least one flower, one panicle, are matured, respectively.

Panicle length was measured using a metre rule. Dry stalk weight was measured, after the stalks were dried to a constant weight using the weighing scale. The total dry weight was determined by adding the weight of the panicles and the dry stalk weight in each net plot area.

$$TDW = Panicle + Stalk\ Weight$$

Where TDW = Total dry weight

Harvest index which is the proportion of the grain yield to the dry weight usually expressed in percentage (Turner, 2004) was estimated by dividing the grain yield by the total dry weight (Stalks + Panicles) multiplied by hundred. For 1000-grain weight, 100 grains were randomly selected from each treatment and were weighed, the weight obtained was multiplied by 10.

The data collected were subjected to Analysis of variance (ANOVA) procedure for Randomized Complete Block Design (RCBD) in GenStat (R) 18th Edition. Thereafter, mean separation was carried out using Duncan's Multiple Range Test (DMRT) at 5% level.

RESULTS AND DISCUSSION

Plant Height, Number of Leaves, Leaf Area and Leaf Area Index: The plant height, number of leaves, leaf area and leaf area index of the sorghum varieties during the trial are presented in Table 1. The plant height ranges from (179.7 – 246.1cm) and was higher in Janjari and Jardawa varieties (238.7 - 246.1cm) than Samsorg 45 and Samsorg 46 (179.7 – 184.9 cm). Yartawa variety was observed to be statically similar with all the varieties.

The number of leaves ranges from (22.83 - 31.57 leaves) and was higher in Yartawa and Jardawa (30.73 – 31.73 leaves) varieties than Samsorg 45 and 46 (22.83-24.60 leaves) varieties. Janjari was observed to be statistically the same with other varieties.

The leaf area ranges from (11928 – 15628cm^2) and was higher in Yartawa (15628cm^2) variety than Samsorg 45, Janjari, Samsorg 46 and Jardawa (11928 - 12798 cm^2). The leaf area index ranges from 5.27 - 6.93 and was not significantly (P> 0.05) different among the sorghum varieties.

Table 1: Plant height, number of leaves per plant, leaf area and leaf area index of sorghum varieties in Sokoto during the 2019 cropping season

Variety	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Leaf area index
Samsorg 45	179.7[b]	24.60[b]	12798[b]	5.70
Samsorg 46	184.9[b]	22.83[b]	12389[b]	5.50
Janjari	246.1[a]	28.20[ab]	12437[b]	5.87
Yartawa	222.7[ab]	31.57[a]	15628[a]	6.93
Jardawa	238.7[a]	30.73[a]	11928[b]	5.27
SEM	13.43	1.783	731.6	0.337
P value	0.023	0.033	0.043	0.056
Significance	*	*	*	NS

*Means followed by same letter(s) within the same column are not significantly different at 5% level. * = Significant at 5% level. NS = not significant at 5% level*

Table 2: Number of days to heading, number of days to flowering, number of days to maturity and panicle length of sorghum varieties in Sokoto during the 2019 cropping season

Variety	Number of days to heading	Number of days to flowering	Number of days to maturity	Panicle length (cm)
Samsorg 45	90.00[a]	97.00[a]	116.0[a]	25.27[b]
Samsorg 46	90.00[a]	97.00[a]	113.3[a]	25.30[b]
Janjari	73.00[c]	87.00[b]	95.0[b]	22.93[b]
Yartawa	83.33[b]	97.33[a]	107.0[a]	24.87[b]
Jardawa	82.00[b]	97.67[a]	110.7[a]	50.33[a]
SEM	1.227	1.877	2.96	1.335
P value	0.01	0.016	0.008	0.01
Significance	*	*	*	*

*Means followed by the same letter(s) within the column are not statistically different at 5%. level. * = Significant at 5% level. NS = not significant at 5% level*

Number of Days to Heading, Number of Days to Flowering, Number of Days to Maturity and Panicle Length: The number of days to heading, number of days to flowering, number of days to maturity and panicle length of sorghum varieties observed during the trial are presented in Table 2. The number of days to heading ranges from (73.00 – 90.00 days) and was earlier (73.00 days) in Janjari variety followed by Yartawa and Jardawa (82.00- 83.33 days) varieties. Samsorg 45 and Samsorg 46 took longer time to heading (90.00 days) among the varieties. The number of days to 50% flowering and maturity range from 87.00 - 97.67 and 95.0 -116.0 days, respectively and was earlier (87.00 and 95.0 days, respectively) in Janjari variety than other varieties (97.00 - 97.67 and 107.0 - 116.0 days, respectively). The panicle length ranges from (22.93 – 50.33 cm) and was taller in Jardawa (50.33cm) variety than other varieties (22.93 – 25.30 cm).

Grain Weight, Dry Stalk Weight, Total Dry Weight, Harvest Index and 1000-Grain Weight: The grain weight, dry stalk weight, total dry weight, harvest index and 1000-grain weight of the sorghum varieties observed during the trial is presented in Table 3. The grain weight of the crop ranges from (249 – 1506 kg ha^{-1}). The highest grain yield (1268 – 1506 kg ha^{-1}) was recorded by Janjari and Yartawa varieties followed by Jardawa (667 kg ha^{-1}) variety and the least (249 – 252 kg ha^{-1}) was recorded by Samsorg 45 and Samsorg 46. The dry stalk weight ranges from (667 – 2309 kg ha^{-1}) and was highest in Janjari (2309 kg ha^{-1}) which was statistically similar with 1671 kg ha-1 recorded by Yartawa variety and the least was recorded by Jardawa (667 kg ha^{-1}) variety which was also similar with 861 – 1049 kg ha^{-1} recorded by Samsorg 45 and 46.

Table 3: Grain weight, dry stalk weight, total dry weight, and harvest index and 1000-grain weight of sorghum varieties in Sokoto during the 2019 cropping season

Variety	Grain weight (kg ha^{-1})	Dry stalk weight (kg ha^{-1})	Total dry weight (kg ha^{-1})	Harvest index (%)	1000-grain weight (g)
Samsorg 45	252[c]	861[bc]	1171[b]	21[b]	22.67[b]
Samsorg 46	249[c]	1049[bc]	1308[b]	19[b]	25.00[b]
Janjari	1506[a]	2309[a]	3942[a]	40[a]	16.67[c]
Yartawa	1268[a]	1671[ab]	3283[a]	38.7[a]	30.33[a]
Jardawa	667[b]	667[c]	1679[b]	38.3[a]	24.67[b]
SEM	157.1	357.3	338.9	4.52	1.293
P value	0.001	0.01	0.001	0.02	0.01
Significance	*	*	*	*	*

*Means followed by the same letter(s) within the column are not statistically different at 5%. level. * = Significant at 5% level. NS = not significant at 5% level*

The total dry weight ranges from (1171– 3947 kg ha^{-1}) and was higher in Janjari and Yartawa (3283 – 3947 kg ha^{-1}) varieties than Jardawa, Samsorg 45 and 46 (1171 – 1679 kg ha^{-1}. The harvest index ranges from (19 – 40%) and was higher in Janjari, Yaratawa and Jardawa (38.3 – 40 %) varieties than Samsorg 45 and Samsorg 46 (19 - 21%) varieties which recorded lower mean value in harvest index. The 1000-grain weight

ranges from (16.67 – 30.33 g) and the highest value (30.33 g) was recorded in Yartawa variety followed by Jardawa, Samsorg 45 and Samsorg 46 (22.67 - 25.00 g) and the least (16.67g) was recorded by Janjari variety.

The taller plants observed in Jardawa and Janjari varieties compared to other varieties could be because of their genetic make-up, and growth habit which is in line with the findings of Ayub *et al*. (1999) who reported that differences in plant height among sorghum varieties can be attributed to differences in genetic characteristic and adaption to weather conditions. The number of leaves per plant recorded in this research (22.83 – 31.57 leaves) was higher than 7 – 24 leaves reported by (Morgan *et al.,* 1987). The higher number of leaves recorded by Yartawa and Jardawa varieties among the tested sorghum varieties could be due to differences in their genetic make-up. This is similar to the findings of Mariotti *et al*. (1976), who reported that stability is associated with the predictability or performance of genotypes in their adaptive potential to advantageously assimilate environmental stimuli. The leaf area recorded in this research (11928 -15628 cm^2) was higher than 1794 – 2259 cm^2 reported by (Munza *et al*., 2018). The higher leaf area observed in, Yartawa variety among the other tested sorghum varieties could be due to its efficient light absorption and utilization which favours vegetative growth. This is in line with the findings of Akram- Ghaderi and Soltani (2007) who reported leaf area in sorghum to be related to photosynthesis, biomass accumulation, transpiration and energy transfer by crop canopies. The leaf area index recorded in this research (5.50 – 6.93 cm^2) was higher than 0.49 -2.29 cm^2 reported by Munza *et al*. (2018) at University of Jos, Nigeria. The number of days to heading recorded in this research 73 – 90 days (mean = 81.5 days) was lower than 86 – 150 days (mean = 118 days) reported by Abdul *et al*. (2018). The early number of days heading observed in Janjari variety among the tested varieties of sorghum could be due to its genetic make-up and its adaptation to environmental conditions. The number of days to flowering observed in this research (87 - 97days) was higher than 66.7 – 76.67 days reported by Abdul *et al*. (2018). The early number of days to flowering recorded by Janjari variety among the tested sorghum varieties could be due to its adaptation to the environmental condition under which the research was carried out. Mariotti *et al*. (1976) reported that flowering time is affected by environmental stimuli where photoperiod is one of the major determinant factors for this trait.

The number of days to maturity observed in this research (95 – 166.0 days (mean = 130.5 days) was lower than 106.3 – 112.7 days (range = 109.5 days) reported by Abdul *et al.* (2018). The early number of days to maturity observed in Janjari variety than other tested sorghum varieties is due to stability and adaptation to the environment findings of Mariotti *et al*. (1976) who reported that stability is associated with performance of genotypes in the face of environmental variation and by their adaptive potential to advantageously assimilate environmental stimuli. The panicle length recorded in this research 22.93 – 50.33 cm (mean = 36.63 cm) was lower than 50 – 60 cm (mean = 55 cm) reported by Doggett (1988). The taller panicles recorded by Jardawa variety compared to the other varieties tested could be due to its growth pattern, which is in line with the finding of Doggett (1988) who reported that inflorescence of sorghum is a determinate panicle which may be compact or open but is usually compact in cultivated lines. The grain yield (252 – 1506 kg ha^{-1}) recorded in this research was lower than 2632 - 3049 kg ha^{-1} reported by Wondimu *et al*. (2005) in their study on the adaptability and stability of forage sorghum cultivars at different times of the year. The higher grain yield recorded by Janjari variety compared to other sorghum varieties tested could be due to its ability to utilize photoperiod and other aspects of the environmental adaptation (Downes, 1972). The weight of dry stalk 667 – 2309 kg ha^{-1} (mean = 1488 kg ha^{-1} recorded in this research was higher than 100 – 700 kg ha^{-1} (mean = 400 kg ha^{-1}) reported by Tabosa *et al*. (2002). The total dry matter 1171 – 3942 kg ha^{-1} (mean = 2556.5 kg ha^{-1}) recorded in this research was lower than 3320 – 15860 kg ha^{-1} (mean = 9590 kg ha^{-1}) reported by Tabosa *et al*. (2002) working with sorghum cultivars in different agro-ecological zones. The higher total dry matter weight observed in Janjari and Yartawa varieties compared to other sorghum varieties tested could be because of their genetic make-up and their ability to adapt to the harsh environmental conditions. Ma (2004) reported that under very dry conditions, leaves curl upwards and inwards, reducing transpiration and moisture loss by decreasing the surface area exposed. The silica deposited on the leaf surface acts as a physical barrier that alleviates water stress by decreasing transpiration and prevents the physical penetration of pests in plant tissues. The harvest index 19 – 40 % (mean = 29.5 %) recorded in

this research was lower than 14 – 70% (mean = 42 %) reported by Unkovich *et al*. (2006) in Australia. The lower harvest index recorded by Samsorg 45 and 46 among the varieties tested could be because of their lower grain yield. This observation agrees with the findings of Turk *et al.* (1980) who reported that environmental stress could reduce the grain yield of sorghum after flowering and thus leading to lower harvest index of the crop. The 1000 grain weight 16.67 – 30.33g (mean= 23.5 g) recorded in this research was lower than 30 – 40g (mean = 35 g) findings of Shiriley *et al* (2011) on Pannar 8609 and Kapala sorghum varieties at Guinea Savanna Zone of Ghana. The higher 1000-grain weight reported by Yartawa among other sorghum varieties tested in 1000-grain weight could be due to it genetic makeup among the environmental factors. This agrees with the findings of ManierJolain and Ney (1998) who reported that variation in individual seed weight account for the differences in yield among environment within species, as well as among species in the same environment.

Conclusion: The results revealed grain yield (249 – 1506 kg ha^{-1}) was higher in Janjari and Yartawa varieties (1268 – 1506 kg ha^{-1}). Based on the finding of this research, it could be concluded that Janjari and Yartawa varieties performed better than other varieties in the study area.

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