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Evaluation of the growth and grain yield of sorghum cultivars (*Sorghum bicolor* L. Moench) in Ekpoma, Nigeria

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ABSTRACT

At the Teaching and Research Farm, Ambrose Alli University, Ekpoma, Edo State, a field study was conducted in 2019 during the cropping season to evaluate the growth and grain yield performance of five sorghum varieties: Samaru local red, Samsorg 42, Samsorg 45, Samsorg 46, and Samsorg 47. With four replicates, the study was done using a Randomized Complete Block Design. Grain yield and yield-related data, as well as growth indicators, were gathered. Samsorg 42 had the highest plant height (254.6 cm) and number of plant^{-1} leaves (13.6), while Samsorg 45 had the lowest plant height (144.4 cm) and number of plant^{-1} leaves (13.6). (6.4). The Samsorg 46 cultivar had the most days to flowering and maturity at 50%. Samsorg 42 had the most seeds panicle-1 (3600), the heaviest 1000 seeds (17.3 g), and the highest grain yield (1529.0 kg ha^{-1}; Samsorg 45 had the fewest seeds panicle^{-1} (1561.0), the heaviest 1000 seeds (12.0 g), and the lowest grain yield (1529.0 kg ha^{-1} (633.0 kg ha^{-1}). In terms of growth and yield, Samsorg 42 was shown to be the most appropriate of the cultivars tested in this zone. However, because the sorghum crop is photoperiod sensitive, more research on the best time to plant should be done.

Keywords: Sorghum; Grain yield; Growth; Performance; Varieties.

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INTRODUCTION

Sorghum is an important crop for Africa and tropical Asia (Kante, et al., 2019). In Africa, sorghum ranks third after maize and rice. Sorghum is cultivated throughout the savanna and humid agro-ecologies of Nigeria. Sorghum grows with an annual rainfall ranging from 400-800 mm (Bibi et al., 2012; Belay & Meresa, 2017; Msongaleli et al., 2017). It is well known to adapt to low nutrient status soil, but well-drained loamy soil is best for sorghum growth and yield.

Sorghum is a vital cereal product, and it is an excellent socio-economic capital for the people of the countries of West Africa (Mishra et al., 2015). In Nigeria, the crop is important to rural dwellers in the Northern zone as grains for human consumption and forage to feed the seemingly increasing ruminant livestock animals. It was reported that sorghum production would increase geometrically from 6.6 to 19.5 million tonnes from 2015-2050 across African countries, thus, triggering the increase of export of the crop yield above 2.5 million tonnes (Mwamahonje & Maseta 2018). Nevertheless, the crop is not given significant priority compared to other cereals like maize, rice, millet and wheat (Remison, 2005; Macauley, 2015). Farmers in the north were observed to search for sorghum seeds due to poor rainfall distribution, where most crops fail to adapt (Shinggu & Gani, 2012).

The adoption of high yielding varieties is emphasized by farmers who still dwell on genotypes with poor yield (Mpangwa, 2011). Research studies on sorghum pointed out that varieties with high yielding ability should be recommended for food security (Saadan et al., 2000; Msongaleli et al., 2017). In Nigeria, agricultural production is low due to a lack of proper agronomic practices, infrastructure, low yields associated with poor soils, low-yielding and less stable varieties (Sallah et al. 2004; Remison, 2005). Regarding climate change, there is a need to increase the effort on research to develop new drought-tolerant varieties of crops like sorghum, millet and other crops in this zone that will withstand the harsh environment in the future to tackle the menace of food insecurity among the populace.

The major tasks faced by farmers in the forest-savanna transition zone is the uncontrolled grazing by herds caused great conflict between croppers and herders. This should be attended to by cultivating crops like sorghum for grain for human consumption and forage for livestock to tackle the menace, thus, creating synergy among farmers and pastoralists in the zone.

MATERIALS AND METHODS

The five varieties of sorghum obtained from the Institute of Agricultural Research, Zaria, Kaduna State, were evaluated in a RCBD with four replicates. The land was manually prepared and the varieties used were: Samaru Local Red, Samsorg 42, Samsorg 45, Samsorg 46 and Samsorg 47. Planting was done on July, 2019 when the rains were fully established.

Twenty plots with twenty-five plants each were involved in giving 500 plants an equivalent to 66,667 plantsha^{-1}, with a total land area of 0.01 ha. The growth and yield parameters were measured at 2, 4, 6, 8, 10, 12, 14 and 16 WAP. SAS (2002) computer analytical software was used to analyze the obtained data.

RESULTS

Plant height has significant differences among the different sorghum varieties. The plant height increased from 2 to 14 WAP in Samsorg 45 and 46; 2 to 16 WAP in Samaru local red, Samsorg 42 and 47. However, the height varied from 144.10 cm in Samsorg 45 to 254.60 cm in Samsorg 42.

The data presented in Table 1 indicate significant differences in the number of leaves plant^{-1}among sorghum varieties throughout the study period. The number of leavesplant^{-1}increased in the crops from 2-14 WAP and declined until 16WAP. At 16 WAP, the number of leavesplant^{-1} varied among varieties from 6.37 to 13.62. The highest and least number of leavesplant^{-1}was for Samsorg 42 and Samsorg 45 with 13.62 and 6.37, respectively.

The results obtained for number of synchronous tillersplant^{-1}revealed significant (P<0.05) differences at 14 and 16 WAP among the varieties (Table 1). The varieties produced no synchronous tillers from 2-12 WAP. However, branching (synchronous tillers) started at 14 WAP and peaked at 16 WAP. Samsorg 42 made the highest number of branchesplant^{-1}(2.00) while Samsorg 45 and 47 varieties had the least values (0.75).

Samaru local red and Samsorg 47 commenced tillering at 8 WAP. Samsorg 46 produced first tiller at 12 WAP while the other varieties started tillering at 14 WAP. At 16, the number of tillersplant^{-1}varied from 0.01 to 1.17. Samsorg 45 produced the highest tillers plant^{-1} (1.17) while Samsorg 42 produced the least (0.01).

The total leaf areaplant^{-1}increased from 2-14 WAP and reduced after that at 16 WAP owing to leaf senescence (Table 1). The result indicates a significant (P<0.05) difference in total leaf area among the sorghum varieties at 4, 6, 12 and 16WAP, while the non-significant difference was observed at 2, 8, 10 and 14WAP. At 16 WAP, the total leaf area varied from 8004.00 cm^2 to 36,740.00 cm^2. The highest (36740.00 cm^2) total leaf areaplant^{-1}was for Samaru local red while the least (8004.00 cm^2) was for Samsorg 46.

There were significant (P<0.05) differences in the stem girth among the five varieties of sorghum throughout the period after planting except at 12 WAP (Table 1). The stem girth increased from 2-14WAP and among the varieties and decreased after that at 16WAP. At 16 WAP, the mean value ranged from 1.51 to 2.54 cm. Samaru local red was significantly the biggest (2.54 cm) while Samsorg 46 was the smallest (1.51 cm).

Significant variations observed in the number of days to 50% maturity among sorghum varieties (Table 2). It was observed that Samaru local red and Samsorg 42 matured late while Samsorg 46, Samsorg 45 and Samsorg 47 matured earlier. The maturity time varied from 113.00 to 137.25 days. Samaru local red recorded the highest days to 50% maturity (137.25 days) while Samsorg 46 recorded the least (113.00 days).

The results in Table 2 showed a significant (P<0.05) difference among varieties studied in the length of terminal panicles. The value ranged from 17.88 to 36.00 cm. Samsorg 42 had the longest panicles (36.00 cm), while the shortest was recorded in Samaru local red (17.88 cm).

Table 1. Vegetative traits of five varieties of sorghum

Parameters/Crop variety	Weeks		after		planting		
Plant height (cm)	2	4	6	8	10	12	14	16
Samaru Local Red	3.89^{ns}	7.57^{ns}	19.61^{ab}	33.90^{ns}	66.10^{ab}	115.80^{ab}	163.20^{ab}	233.60^{a}
Samsorg 42	3.87	8.12	21.73^{a}	41.80	84.80^{ab}	137.90^{a}	195.40^{a}	254.60^{a}
Samsorg 45	3.27	5.72	14.37^{b}	31.60	74.10^{ab}	115.20^{ab}	144.10^{b}	144.10^{b}
Samsorg 46	3.87	7.66	19.67^{ab}	48.80	97.00^{a}	135.60^{a}	147.20^{b}	147.20^{b}
Samsorg 47	3.37	6.68	18.50^{ab}	33.10	59.60^{b}	88.90^{b}	128.90^{b}	150.6^{ab}
No. of leavesplant^{-1}								
Samaru Local Red	4.50^{ab}	6.88^{a}	8.75^{a}	9.81^{ab}	11.06^{b}	12.12^{b}	13.38^{b}	12.31^{a}
Samsorg 42	4.93^{a}	7.06^{a}	8.69^{a}	9.60^{ab}	11.00^{b}	12.50^{b}	14.44^{ab}	13.62^{a}
Samsorg 45	4.31^{b}	4.88^{b}	7.06^{b}	8.50^{b}	9.69^{b}	9.75^{c}	9.88^{c}	6.37^{b}
Samsorg 46	4.31^{b}	6.31^{a}	8.19^{ab}	8.69^{b}	10.00^{b}	10.31^{c}	10.00^{c}	6.81^{b}

Samsorg 47	4.69 ^{ab}	6.88^{a}	9.25^{a}	10.88^{a}	12.56^{a}	13.88^{a}	16.44^{a}	13.44^{a}
No. of synchronous tillersplant^{-1}								
Samaru Local Red	0.00^{ns}	0.00 ^{ns}	0.00 ^{ns}	0.00 ^{ns}	0.00 ^{ns}	0.00 ^{ns}	1.25^{b}	1.25^{b}
Samsorg 42	0.00	0.00	0.00	0.00	0.00	0.00	2.00^{a}	2.00^{a}
Samsorg 45	0.00	0.00	0.00	0.00	0.00	0.00	0.75 ^{c}	0.75 ^{c}
Samsorg 46	0.00	0.00	0.00	0.00	0.00	0.00	1.08 ^{b}	1.08 ^{b}
Samsorg 47	0.00	0.00	0.00	0.00	0.00	0.00	0.75 ^{c}	0.75 ^{c}
Total leaf areaplant^{-1}(cm^{2})								
Samaru Local Red	117.7^{ns}	1380.0^{a}	7104.0^{ab}	15025.0	26414.0^{ns}	26375.0^{ab}	42674.0^{ns}	36740.0^{a}
Samsorg 42	108.6	1650.0^{a}	7268.0^{a}	14939.0	25158.0	29608.0^{ab}	36892.0	33504.0^{a}
Samsorg 45	79.9	447.0^{b}	3534.0^{b}	8099.00	17394.0	17822.0^{b}	19491.0	12410.0^{b}
Samsorg 46	107.3	1269.0^{ab}	6796.0^{ab}	12294.0	18887.0	18980.0 ^{b}	19492.0	8004.0^{b}
Samsorg 47	122.6	1179.0^{ab}	5647.0^{ab}	53655.0	23243.0	32876.0 ^{a}	41992.0	34650.0^{a}
Stem girth (cm)								
Samaru Local Red	0.21^{ab}	0.56^{a}	1.31^{a}	1.93^{a}	2.49^{a}	2.55^{ns}	2.59^{a}	2.54^{a}
Samsorg 42	0.23^{a}	0.60^{a}	1.30^{a}	1.89^{a}	2.07^{ab}	2.26	2.22^{ab}	1.97^{b}
Samsorg 45	0.19^{b}	0.36^{b}	0.91^{b}	1.37^{c}	1.64^{c}	1.87	1.91^{bc}	1.67^{c}
Samsorg 46	0.22^{ab}	0.54^{a}	1.19^{ab}	1.49^{bc}	1.79^{b}	1.91	1.68^{c}	1.51^{c}
Samsorg 47	0.20^{ab}	0.54^{a}	1.1^{ab}	1.76^{ab}	2.21^{ab}	2.31	2.40^{ab}	2.37^{a}
No. of tillersplant^{-1}								
Samaru Local Red	0.00^{ns}	0.00^{ns}	0.00^{ns}	0.50^{ns}	0.50^{ns}	0.50^{ns}	0.50^{b}	0.50^{b}
Samsorg 42	0.00	0.00	0.00	0.00	0.00	0.00	0.01^{c}	0.01^{c}
Samsorg 45	0.00	0.00	0.00	0.00	0.00	0.00	0.88^{a}	1.17^{a}
Samsorg 46	0.00	0.00	0.00	0.00	0.00	0.25	0.25^{c}	0.38^{b}
Samsorg 47	0.00	0.00	0.00	0.50	0.50	0.50	0.50^{b}	0.38^{b}

Table 2. Flowering and maturity traits, grain yield and yield components of five varieties of sorghum

Crop variety	Days to 50% flowering	Days to 50% maturity	No. of terminal panicles	Panicle length (cm)	No. of seeds panicle^{-1}	Grain Yield (kg ha^{-1})	Weight of 1000 seeds (g)	Terminal panicle weight (kg ha^{-1})	Husk weight (kg ha^{-1})
Samaru Local red	116.0^{a}	137.2 ^{a}	1.0 ^{ns}	17.9 ^{c}	1609.0 ^{b}	1017.0 ^{bc}	13.8 ^{b}	3244.0^{a}	2227.0^{a}
Samsorg 42	114.5 ^{a}	136.0 ^{a}	1.0	36.0 ^{a}	3600.0 ^{a}	1529.0 ^{a}	17.3 ^{a}	2400.0^{b}	1121.0^{b}
Samsorg 45	98.5 ^{c}	118.5 ^{c}	1.0	20.1 ^{c}	1561.0 ^{b}	633.0 ^{cd}	12.0 ^{d}	1165.0^{d}	531.0^{c}
Samsorg 46	93.0 ^{d}	113.0 ^{c}	1.0	21.3 ^{bc}	1658.0 ^{b}	812.0 ^{c}	12.3 ^{cd}	1490.0^{c}	610.0^{c}
Samsorg 47	108.0 ^{b}	129.5 ^{b}	1.0	27.1 ^{b}	2111.0 ^{b}	1242.0 ^{ab}	13.5 ^{bc}	2610.0^{b}	1368.0^{b}

The results on the terminal panicle weight revealed significant variations among the five varieties (Table 2). The terminal panicle weight varied from 1165.00 to 3244.00 kgha^{-1}. The highest and least weight of terminal panicles were for Samaru local red (3244.00 kg ha^{-1}) and Samsorg 45 (1165.00 kg ha^{-1}).

Husk weight

The husk weight (Table 2) showed a significant change among the varieties. The mean ranged from 531.00 kgha^{-1} to 2227.00 kgha^{-1}. Samaru local red had the highest husk weight (2227.00 kgha^{-1}), while the lowest weight (531.00 kgha^{-1}) was recorded for Samsorg 45.

Weight of 1000 seeds

Significant variations on the weight of 1000 seeds (Table 2). The value varied from 12.00 to 17.25 g. Samsorg 42 significantly had the highest 1000 seeds weight (17.25 g) while Samsorg 45 had the least (12.00 g).

Grain yield

Table 2 showed that the three late-maturing varieties of sorghum yielded significantly more grain per hectare than the two early maturing varieties (Table 2). The grain yield ranged from 633.00 to 1529.00 kgha^{-1}. Samsorg 42 out-yielded the other varieties (1529.00 kgha^{-1}) while Samsorg 45 had the least (633.00 kgha^{-1}).

Relationship between vegetative parameters and grain yield of sorghum

The plant height, total leaf areaplant^{-1}, stem girth and number of synchronous tillersplant^{-1} had positive and non-significant relationship with grain yield (r= 0.667, r= 0.767, 0.471 and r= 0.704).

Table 3. Relationship (r) between vegetative parameters and grain yield of sorghum

	No. of leaves plant^{-1}	Total leaf area plant^{-1}	Stem girth	No. of synchronous tillers plant^{-1}	Number of tillers plant^{-1}	Grain yield
Plant height	0.661^{ns}	0.677^{ns}	0.459^{ns}	0.878^{ns}	-0.582^{ns}	0.677^{ns}
No. of leaves plant^{-1}		0.963**	0.806^{ns}	0.480^{ns}	-0.687^{ns}	0.901*
Total leaf area plant^{-1}			0.916*	0.382^{ns}	-0.505^{ns}	0.767^{ns}
Stem girth				0.051^{ns}	-0.256^{ns}	0.471^{ns}
No. of synchronous tillers plant^{-1}					-0.721^{ns}	0.704^{ns}
No. of tillersplant^{-1}						-0.852^{ns}

DISCUSSION

Growth performance is an attribute of genetic constituents and environmental conditions prevalent at the growing periods. In this study, it was observed that Samsorg 42 which had the highest plant height significantly yielded the highest grains. Ghosh et al. (2015) reported the highest yield from the sorghum variety with the highest plant height among 20 varieties tested. This report does not concur with Omoregie & Nwajei (2015) report, who observed that as the height of millet increases, the grain yield tha^{-1}area^{-1} decreased. In this study, Samsorg 42, with high yielding ability, proved significantly different in plant height and the final yield from other varieties. Such finding emphasized the importance of plant height as an important growth attribute in determining the crop's final yield.

The number of leavesplant^{-1}was found to contribute highly in enhancing both growth and yield in sorghum (Abduselam et al., 2018). It was observed that Samsorg 42, having greater number of leavesplant^{-1}, produced a significantly higher yield than other varieties studied. This may be because more leaves produced enhanced higher photosynthesis at the exponential growth phase of the crop. According to Staggenborg (2016), increase in number of leavesplant^{-1} increased photosynthetic matter accumulation.

Tillering in sorghum plays major role in yield determination in sorghum. According to Obeng et al. (2012) and Omoregie & Nwajei (2015), synchronous tillers emerge from the base of the leaf buds. However, most of the synchronous tillersplant^{-1} produced by the sorghum varieties did not survive till maturity. The crop with a high number of tillers can produce more seed yield compared to the varieties with a low number of tillers (Nwajei et al., 2019). This also depends on the agronomic management and the genetic component expressing the phenotypes (May et al., 2014). Although the number of tillers and synchronous tillers produced by the crops contributed immensely to the vegetative performance, these could not produce grain yield due to senescence before yield evaluation. This result is in disagreement with the reports of Obeng et al. (2012); Omoregie & Nwajei (2015) and Nwajei et al. (2019).

Total leaf area of a plant plays an important role in photosynthesis and hence in the growth and yield of a plant. Generally, total leaf area may have contributed significantly to the vegetative performance of the plants and the grain yields due to photosynthetic material accumulated. Although Samaru local red gave higher total leaf areaplant^{-1} than other varieties, the difference was not significant from those of Samsorg 42 with the highest grain yield. The result obtained is in line with those of Belay & Meresa (2017), who emphasized the role of this vegetative trait in selecting superior genotype for grain production.

The stem girth is important in the resistivity and susceptibility of crops to lodging conditions (Nwajei et al., 2019; Omoregie et al., 2021). Samaru local red is likely to show higher resistance to wind and other lodging effects while Samsorg 46 may be more susceptible to these conditions. However, the significant bigger culm produced by Samaru local red is an advantage in wind resistance. Staggenborg (2016) and Mwamahonje & Maseta (2018) reported a significant difference in stem girth among sorghum genotypes. Omoregie et al. (2021) reported significant resistant effects for bigger culms to lodging conditions in sorghum.

Flowering is one of the traits which is used in the selection of a variety. The early flowering sorghum is preferred to short raining period, especially in drought-prone areas, where sorghum is commonly cultivated (Belay & Meresa, 2017). Days to 50 per cent flowering & maturity of sorghum varieties are important in determining early and late grain production systems (Mwamahonje & Maseta, 2018). Sorghum is a quantitative short-day plant as long day sensitivity delay floral initiation in some varieties. Days to flowering predict maturity; early flowering varieties have high possibility of maturing first. Samsorg 46 was earliest in days to 50% flowering and maturity. However, it was observed that medium ripened varieties with longer period of growth yielded more grains. This result agrees with the findings by Belay & Meresa (2017); Msongaleli et al. (2017) and Mwamahonje & Maseta (2018), who stated that medium maturing varieties exhibit longer growth period and contribute immensely to grain yield.

Panicle length is a primary factor in crop productivity (Nwajei et al., 2019). It was observed that the longer the panicles and higher the number of grains obtained. These varieties differ significantly in panicle length and number of grainspanicle^{-1}, which can be attributed to the plant's genetic makeup and environment. Kotu & Admassie (2015); Staggenborg (2016) and Msongaleli et al. (2017) reported that head length is a primary factor of grain production. Omoregie & Nwajei (2015) and Nwajei et al. (2019) reported that millet varieties with longer panicles had a higher number of grains. The present study of sorghum, a cereal, agrees with the results of these previous studies. It was found that the size of the panicle influenced the yield from grainshead^{-1}panicle^{-1}. The variation in head or panicle weight was indicated by the quantity of seeds produced and varied among the varieties. This observation conforms with those of Msongaleli et al. (2017), who found a significant difference in panicle yield due to varietal response and the grains produced. The husk weight was significantly different among varieties. There was a significant difference in weight per 1000 seeds among varieties. The significant difference in 1000 seeds weight observed for Samsorg 42 was due to varietal characteristics of the crop. Similar results were reported by Staggenborg (2016) and Msongaleli et al. (2017) that the presence of varietal characteristics may result in variability in seed weight.

The grain yield is an important component for selecting crop varieties. There were significant variations in the grain yield among the sorghum varieties studied. However, considering the overall grain performance from Samsorg 42 variety, the various components of yields estimated contributed immensely towards this higher total grain yield by the crop variety. This report is in line with those of Kotu

& Admassie (2015); Staggenborg (2016); Msongaleli et al. (2017) and Mwamahonje & Maseta (2018), who observed high grain yield of sorghum varieties due to genes and the environmental conditions which prevailed.

It has been established that traits like; plant height, number of leavesplant^{-1} and total leaf areaplant^{-1} have a significant contribution to the final grain yield in sorghum crops (Saadan et al., 2000). Plant height gets prime importance while determining sorghum yield (Omoregie et al., 2021). This is an indication that these vegetative traits contributed immensely to grain yield of the crop.

Generally, higher plant height, number of leavesplant^{-1}, leaf areaplant^{-1}, stem girth and number of synchronous tillersplant^{-1} significantly impact the final grain yield of sorghum. Extremely tall plants experience instability in stand establishment and susceptibility to wind effect, thus lodging under high winds. According to May et al. (2014), medium plant height between 100– 200 cm is favourable for stand stability and enhances resistance to wind effect and other lodging conditions.

CONCLUSION

In this study, Samsorg 42 performed best in terms of growth and yield characters of all varieties tested and therefore best suited to forest-savanna transition zone (Ekpoma), Nigeria.

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