AGRONOMIC PERFORMANCE OF FIVE SORGHUM VARIETIES IN A HUMID TROPICAL ZONE AS INFLUENCED BY FERTILIZER RATES

Ndukwe, O. O.[1*], Okondor, P. I.[1], Uko, I.[1], Obidiebube, E. A.[1], Okolie, H.[1], Apalowo, O. A. and Orji, C. M.[1, 2]
[1]Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Nigeria
[2]IFAD Assisted Value Chain Development Programme, Awka, Nigeria

*Corresponding author email: oo.ndukwe@unizik.edu.ng

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ABSTRACT
The phenology, growth and yield performance of four new varieties of sorghum as influenced by NPK 15:15:15 rates were evaluated in Awka, Anambra State Nigeria, a humid tropical zone. The new varieties, Improved Deko, SK-5912, KSV-8 and CSR-01 were evaluated alongside Bida Local, an existing Nigerian sorghum landrace whereas NPK rates comprised 0, 200 and 400 kg/ha. Experimental design was 3 x 5 factorial experiment in randomized complete block design (RCBD). The findings showed significant (P<0.05) interaction effect on phenology of sorghum. All the new varieties significantly flowered and matured earlier than the landrace. Earliest flowering (≈ 69 days) and grain maturity (≈ 111 days) were recorded in Improved Deko across the NPK rates whereas latest flowering (≈ 114 days) and harvest (≈ 154 days) were observed in Bida local. This implied that the Improved Deko flowered (45 days) and matured (43 days) earlier than the Bida Local across the NPK rates. Bida Local produced more number of leaves with wider stems than the new varieties especially at 90 days after planting while fewest number of leaves and narrowest stems were observed in Improved Deko. Although there was a progressive increase in growth (plant height, number of leaves, stem girth) with increase in NPK rates but the mean values recorded with 200 kg/ha NPK application were significantly at par with those obtained with 400 kg/ha NPK application. Highest panicle weight (67.5 g/plant) and grain yield (2.33 t/ha) were significantly (P<0.05) recorded in SK-5912 when the variety received 200 kg/ha NPK. This grain yield (2.33 t/ha) from SK-5912 was higher than the world average sorghum production (1.45 t/ha) Varieties SK-5912, KSV-8 and CSR-01 and Improved Deko had 145.84%, 50.26% and 35.09% grain yield increase with 200 kg/ha NPK when compared to the local variety. The results obtained from the study showed that SK-5912, KSV-8 and CSR-01 sorghum varieties can adapt favourably to a humid region of Awka agricultural zone of Anambra State, Nigeria especially when the soil is amended with 200 kg/ha NPK.

Keywords: Sorghum, growth, adaptation, panicle, grain, yield.

1. INTRODUCTION
Grain sorghum is one of the most important cereal crops in the world as more than five hundred million people depend on the crop for their dietary staple (ICRISAT, 2022a). It one of the crops, besides rice (*Oryza sativa* L.), maize (*Zea mays*, L.), wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and oats (*Avena sativa* L.), that have been noted as major agronomic crops for food security (Adviento-Borbe, 2020). Grain sorghum (*Sorghum bicolor* L. Moench) originated in Africa and India. However, the United States is the world's largest

producer of grain sorghum followed by India, Mexico and Nigeria (ICRISAT, 2022a). It is a leading cereal grain produced in Africa.

Sorghum has been reported to have multiple uses ranging from food, fodder, feed, pharmaceutical diagnosis and fuel (Aruna and Visarada, 2019). Sorghum grain is increasingly utilized for human consumption, due to the health benefits as attributed to its gluten-free content and rich in bioactive phenolic compounds known to provide many health benefits, including antioxidant, anti-inflammatory, anti-proliferative, anti-diabetic, and anti-atherogenic activities (Xu *et al*., 2021). Sorghum whole grain or grain with the pericarp can be boiled and consumed. Generally, the grain is ground into flour and made into porridge (in Africa) or flat unleavened bread (in India). Sorghum grain is used for brewing beer in parts of Africa, and for alcoholic wine in China. Sorghum is among the most common food crops in Africa as the rate of human consumption comprises about 40% of total world production (Adiamo *et al*., 2018).

The nutritional value of grain sorghum is outstanding compared to other important cereals in the world. It is rich in carbohydrate, iron, vitamin B6, niacin, phosphorus and magnesium (Edia, 2019). Protein in sorghum grain is gluten free and, thus, it is a specialty food for people who suffer from celiac disease (intolerant to food with gluten), including diabetic patients (Kumar et al., 2015).

Sorghum is rich in carbohydrates, iron, magnesium, potassium, calcium and phosphorus but low in protein and other essential minerals such as vitamin A and zinc. Bio-fortifying the crop with essential minerals, vitamins and other nutrients that are in limited quantity could be a cost-effective tool in the battle against malnutrition and hidden hunger in communities that depend on a single crop, all year round (Taylor and Taylor, 2011, Lipkie *et al*., 2013). Realizing these facts, International Crops Research Institute for Semi-Arid Tropics (ICRISAT) successfully bred and released hybrids which are undergoing locational trials for adaptation. The new sorghum varieties developed in Nigeria and released to farmers are naturally bio-fortified and have more iron content and yields higher than the local varieties.

In Nigeria, sorghum production has often been attributed to only the Northern part of Nigeria (Yahaya *et al*., 2022) whereas most of its industrial uses are predominantly located in the South East and Western Nigeria. Research on production of sorghum in these southern region of Nigeria, especially improved varieties, will provide information on the adaptability of the crop in this region. Successful adaptation and production of the crop in the region will reduce the cost of transporting the grains from the Northern regions thereby reducing the cost of production of various products in the industries. The industrial sector in Nigeria utilizes 20% and 80% of the 5.5 million metric tonnes of sorghum grains as materials for the production of food/beverages and livestock feeds, respectively (Alli, 2017). Although, the productivity of sorghum in the Nigeria is low (≤1.0 t/ha) due to several production constraints (Yahaya *et al*., 2022) but efforts are made to increase the production since Nigeria is the leading sorghum producer, followed by Ethiopia in Africa.

On the other hand, low soil fertility has been noted as one of the major constraints to sorghum production aside other abiotic and biotic stresses such as drought, high temperatures, acid soils, weed competition, pests and diseases (ICRISAT, 2022a). Soils in Nigeria fall under sub-saharan African soils characterized by low fertility due to erosion, nutrient loss and organic carbon as a result of continuous cropping (Jones et al., 2013). Farmers have resorted to the application of exogenous substances in order to improve the fertility status of cropping areas during production. Increase of sorghum production and improvement of quality characteristics through utilization of fertilizer is one of the important methods of yield increase (Tonitto et al., 2016; Muhammed et al., 2018). Adequate soil nutrition is necessary to meet the growth and yield potential of sorghum and it is necessary to review soil management programs so as to ensure long-term sustainability of high quality grain production (GRDC, 2017) and the two principal nutrients required for successful production of sorghum are nitrogen and phosphorus. Msongaleli et al. (2017) observed the report of previous experiments that grain yields of improved sorghum varieties vary among varieties and across locations as well as seasons. Therefore, the objective of the study was to evaluate the growth and yield of four newly released varieties of sorghum alongside a local variety in a humid zone of Nigeria as influenced by varying rates of NPK 15:15:15 fertilizer.

2. MATERIALS AND METHODS

The experiment was carried out in the experimental farm of Delfarm Anambra-Songhai Projects Limited, Igbariam, Anambra State, Nigeria. The site falls under Anambra agricultural zone of Anambra State and lies on latitude 06° 14´N and longitude 06° 45´E. The rainfall pattern is bimodal between April and October with an average annual rainfall of 1268 mm. The prevailing relative humidity is 73.75% while maximum and minimum temperatures are 33°C and 23°C, respectively.

The experimental treatments comprised four improved sorghum varieties (Improved Deko, SK-5912, KSV-8 and CSR-01) and a local variety, Bida Local. These sorghum varieties received three rates of NPK 15:15:15 (0, 200, 400 kg/ha). The sorghum seeds were obtained from the International Crop Research Institute for the Semi-Arid and Tropics (ICRISAT) Headquarters, Kano, Nigeria. The seeds were treated with star dress (a seed dress) to prevent soil-borne pathogens. These were laid out as a 3 x 5 factorial experiment in randomized complete block design (RCBD) and replicated three times.

The experimental site was ploughed, harrowed and then ridged. Each ridge was 50 cm apart from another adjacent ridge (measured from the crests of the ridges). The ridged land area was partitioned into 3 m x 3 m plots. Sowing of sorghum seeds was done manually on the crest of the ridge at 4 seeds per hole. The seeds were sown at a plant spacing of 25 cm x 75cm. Missing stands were supplied a week after seedling emergence.

The type of fertilizer used was NPK 15:15:15. Band method was used during the fertilizer application. The plants received 0, 2.5 and 5 g of the fertilizer which were the actual quantity that represented the 0, 200 and 400 kg/ha of NPK 15:15:15. Fertilization was done at 5 weeks after seed sowing. Weeding was done thrice during the growing period as at when due. The weeding was manually done with hoe.

Data were collected from ten middle-most plants per plot. The phenological parameters were number of days to first, 50%, and 100% flowering. Others include average days to flag leaf appearance, days to harvesting and days to fruit filling. Growth parameters included plant height, number of leaves, stem diameter. Plant height (cm) was measured with the aid of a flexible meter tape from the ground level to the point of attachment of the last and youngest leaf to the stalk. This was measured at 30, 60, 90 days after sowing. Number of leaves was obtained by counting all the green leaves of the ten plants at 30, 60, 90 days after sowing. Stem diameter (mm) was measured by using a digital vernier caliper at 10 cm above the ground level. The yield attributes

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recorded at harvest were panicle length, panicle weight, grain weight and yield. The panicle length was measured with a meter tape, from the tip to the base of the panicle. Panicle weight was determined with a sensitive weighing scale, to the nearest gram (g). The grains per panicle per plant were threshed manually and weighed with the sensitive weighing scale in order to determine the grain weight (g).

All the data collected were subjected to analysis of variance following the procedure for factorial experiment in randomized complete block design (RCBD) using GENSTAT (2007). Significant differences between treatment means were determined using least significance difference at 5% level of significance.

3. RESULTS

The textural class of the soil of the experimental site was sandy loam (Table 1). The chemical properties showed that the soil pH was slightly acidic and the fertility status of the soil before planting relatively poor considering the concentration of the analyzed soil elements as presented in Table 1.

Table 1: Physicochemical properties of the soil used in the study

Parameters	Values
Physical Properties	
Sand (%)	80.24
Silt (%)	11.0
Clay (%)	8.76
Textural class	Sandy loam
Chemical Properties	
pH (water)	6.7
Total nitrogen (%)	0.34
Available phosphorus (mg/kg)	2.2
K^+ (cmol/kg)	0.2
Ca^{2+} (cmol/kg)	6.0
Mg^{2+} (cmol/kg)	2.5
Organic carbon (%)	3.34
Organic matter (%)	5.75
Exchangeable H^+ (cmol/kg)	2.25
Al^{3+} (cmol/kg)	1.25

Main effects of variety and NPK fertilizer rates on percentage emergence and phenology of Sorghum

The main effect of variety on the phenology of sorghum indicated that average days to first and 50% emergence, days to flag leaf appearance and harvesting were significantly ($P<0.05$) earliest in Deko variety (Table 2). These phenological parameters were latest in the Bida local variety but number of days to 100% emergence were not significantly ($P>0.05$) different among the varieties. Number of days to grain filling was longest in SK-S912 variety.

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The NPK rates significantly (P<0.05) influenced the number of days to first and 50% flowering. First and 50% seedling emergence were earliest when the sorghum received 200 kg/ha NPK. No application of fertilizer delayed the flowering of the plants.

The combined effect of variety and NPK rates influenced the number of days to first, 50% flowering, days to flag leaf appearance, grain filling and harvesting (Table 3). Both percentage emergence and days to 100% flowering were not significantly influenced by variety and NPK rates interaction. Deko variety had shortest days before first (68-70 days) and 50% flowering (≈68 days) irrespective of the NPK rates received. The variety also produced their flag leaves (65-77 days) and matured (≈111 days) earliest regardless of the NPK rates that were applied to them. Number of days to grain filling (≈40 days) was shortest in KSV-8 with application of 400 kg/ha NPK, although the mean number of days were statistically similar with CSR-01 and Bida local with 200 kg/ha NPK application. However, longest days (55-57) were significantly spent in grain filling by SK-5912 variety notwithstanding the NPK rates. Longest days to first (109-113 days), 50% flowering (109-112 days), flag leaf appearance (104-107 days) and harvesting (153-155 days) were attributed to Bida local that received either of the NPK rates.

Table 2: Main effect of variety on percentage emergence and phenology of sorghum

	Days to first flowering	Days to 50% flowering	Days to 100% flowering	Days to flag leaf appearance	Days to grain filling	Days to harvesting
Variety						
Bida Local	110.42	110.00	116.3	105.26	43.56	159.96
CSR-01	76.71	77.00	82.7	72.61	41.96	118.64
Deko	69.04	68.00	75.7	69.33	41.94	110.98
KSV-8	76.34	75.89	121.7	71.99	41.41	117.79
SK-5912	84.24	82.78	89.2	79.27	56.16	140.44
$LSD_{0.05}$	1.99	2.20	ns	6.21	2.244	0.77
NPK rate (kg/ha)						
0	82.69	82.20	88.5	80.82	45.67	128.35
200	83.90	83.33	114.1	79.37	44.38	128.31
400	83.46	82.67	88.7	78.88	44.96	128.42
$LSD_{0.05}$	1.54	1.70	ns	ns	ns	ns

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Table 3: Interaction effect of variety and NPK rates on phenology of sorghum

Variety	NPK rate (kg/ha)	Days to first flowering	Days to 50% flowering	Days to 100% flowering	Days to flag leaf appearance	Days to grain filling	Days to harvesting
Bida Local	0	109.89	109.00	114.3	104.89	44.77	154.67
	200	112.51	112.00	119.3	107.28	40.75	153.20
	400	108.85	109.00	115.3	103.59	45.17	154.03
CSR-01	0	76.17	76.33	83.0	71.90	42.26	118.38
	200	78.06	79.00	83.7	74.03	40.74	118.77
	400	75.91	75.67	81.3	71.91	42.87	118.78
Deko	0	68.07	67.67	75.0	77.27	42.89	110.97
	200	69.26	68.33	75.3	65.12	41.81	111.07
	400	69.79	68.00	76.7	65.59	41.11	110.90
KSV-8	0	75.74	75.33	81.0	71.40	41.52	117.26
	200	75.53	75.00	202.3	71.25	42.43	118.10
	400	77.73	77.33	81.7	73.33	40.27	118.00
SK-5912	0	83.57	82.67	89.0	78.66	56.91	140.49
	200	84.12	82.33	90.0	79.17	56.17	140.43
	400	85.03	83.33	88.7	79.98	55.37	140.40
$LSD_{0.05}$		3.45	3.81	ns	10.76	3.887	1.34

Main effects of variety and NPK rates on plant height, number of leaves and stem girth of sorghum

The main effect of variety on plant height, number of leaves and stem girth of sorghum at 30, 60 and 90 days after planting are presented in Table 4. At 30 and 90 days after planting, CSR-01 variety recorded tallest plants but at 60 DAP, Deko variety produced tallest plants. Shortest plants were produced by Bida local at 30 DAP and SK-5912 at 60 and 90 days after planting. Number of leaves were not significantly (P>0.05) different among the varieties at 30 DAP. But at 60 and 90 DAP, Bida local produced highest number of leaves while lowest numbers of leaves were produced by Deko variety. Stem diameter was thickest in Bida local and CSR-01 at 30 days after planting. Bida local also produced thickest stems at 60 and 90 DAP. Stems of Deko, KSV-8 and SK-5912 were tiniest at 30 DAP while CSR-01, Deko, KSV-8 and SK-5912 had tiniest stems at 60 DAP. At 90 DAP, CSR-01, Deko, KSV-8 produced tiniest stems.

NPK rates on the other hand did not significantly influence the growth parameters at the periods of sampling except at 90 DAP (Table 4). Plants were tallest with the application of 400 kg/ha NPK although there was no significant (P>0.05) variations with the mean values obtained with the application of 200 kg/ha NPK. The stem diameter followed the similar trend as the plant height. Plots that received no fertilizer produced shortest plants with tiniest stems. The number of leaves were not significantly (P>0.05) influenced by NPK rates.

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Table 4: Main effects of variety and NPK rates on plant height, number of leaves and stem girth of sorghum

	30 DAP			60 DAP			90 DAP		
	Plant height (cm)	No. of leaves	Stem diameter (mm)	Plant height (cm)	No. of leaves	Stem diameter (mm)	Plant height (cm)	No. of leaves	Stem diameter (mm)
Variety									
Bida Local	10.8	5.38	5.91	50.2	8.05	20.60	167.7	12.97	23.12
CSR-01	13.5	5.46	5.59	48.5	6.78	13.90	182.4	9.01	12.83
Deko	11.9	5.29	4.92	51.6	5.96	12.46	133.7	6.66	11.24
KSV-8	12.2	5.58	5.11	45.2	6.48	12.88	169.1	8.05	11.64
SK-5912	11.9	5.38	4.38	31.2	6.04	12.42	89.3	10.44	16.76
$LSD_{0.05}$	ns	ns	ns	10.7	0.85	2.78	31.8	0.98	2.05
NPK rate (kg/ha)									
0	12.2	5.49	4.92	44.5	6.56	13.35	132.8	9.19	14.12
200	12.1	5.39	5.34	45.5	6.50	14.82	152.7	9.50	15.20
400	11.9	5.36	5.29	45.9	6.92	15.19	159.9	9.59	16.04
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	24.6	ns	1.59

***ns means not significant**

Interaction effect of variety and fertilizer rates on growth of sorghum

Significant (P>0.05) interaction effect of variety and NPK rates on plant height, stem girth and number of leaves were recorded at 90, 60 and 60 days after planting, respectively. Varieties CSR-01 and Bida Local were tallest (202 cm and 193.6 cm) especially with the application of 400 kg/ha NPK while SK-5912 produced shortest plants irrespective of the NPK rate. On the other hand, Bida Local produced highest number of leaves with widest stems with the application of either 200 or 400 kg/ha NPK. Similar trend was observed at 90 DAP, although the mean values were statistically at par.

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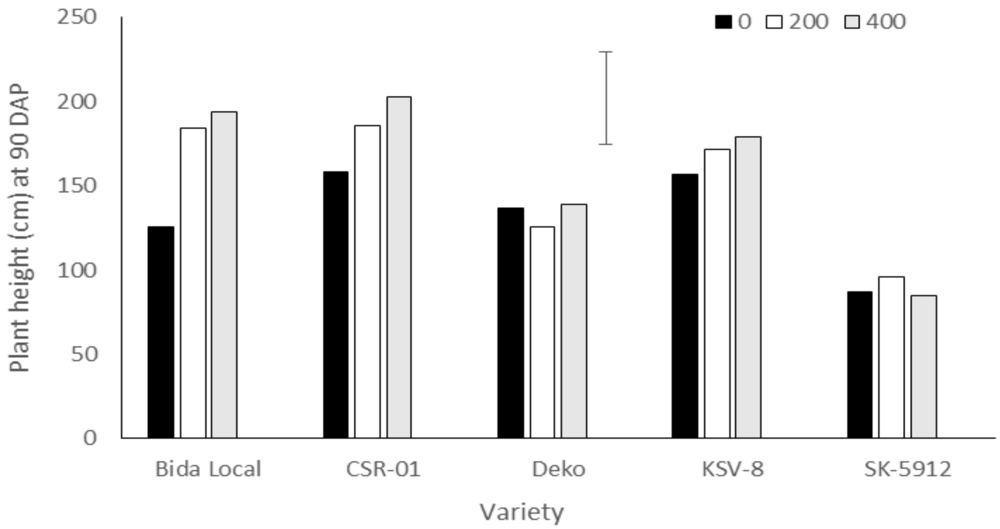

Fig. 1. Interaction effect of variety and NPK rates on plant height at 90 days after planting (DAP). Vertical bar represents least significant difference (55.07) at 5% level of significance

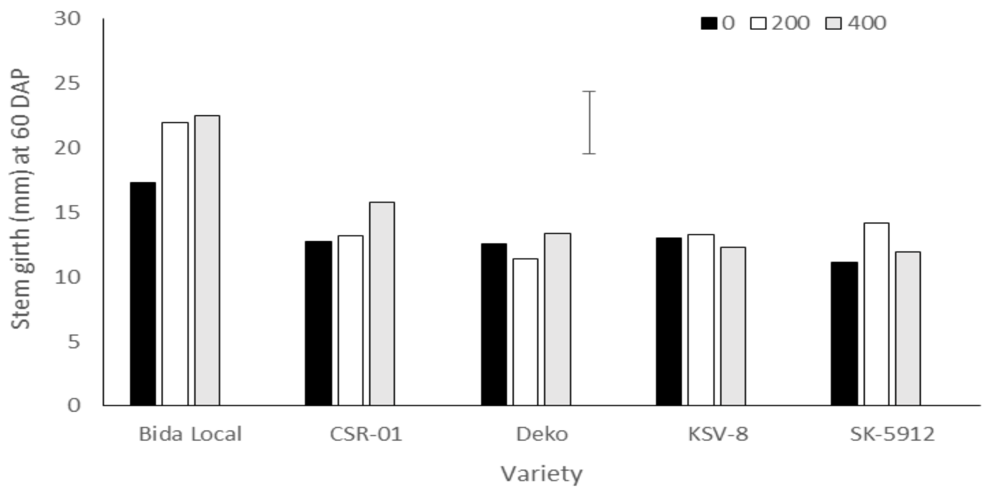

Fig. 2. Interaction effect of variety and NPK rates on stem girth at 60 days after planting (DAP). Vertical bar represents least significant difference (4.81) at 5% level of significance

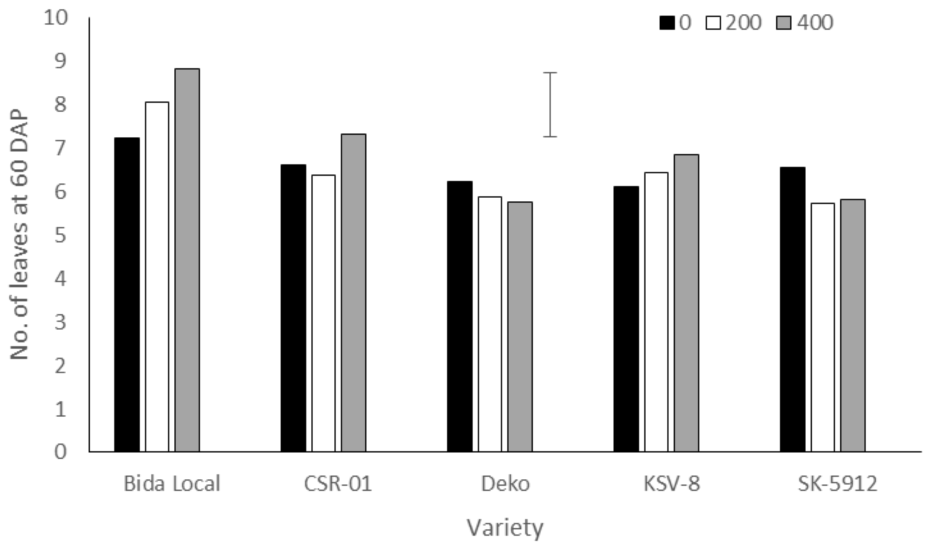

Fig. 3. Interaction effect of variety and NPK rates on number of leaves at 60 days after planting (DAP). Vertical bar represents least significant difference (1.48) at 5% level of significance

Main effect of variety and NPK rate on some yield parameters of sorghum

Results of the yield parameters revealed that the Bida Local significantly ($P<0.05$) produced longest panicle (54.48 cm) while the shortest panicles (30.78 cm) were produced by SK-5912 (Table 5). On the other hand, there was no significant difference in the number of panicle among the varieties. Panicle weight significantly differed ($P<0.05$) among the varieties. SK-5912 variety produced heaviest panicles (56.5 g/plant) and grains (34.9 g/plant) but the lowest panicle and grain weight were recorded with Bida Local and Deko varieties. Correspondingly, SK-5912 significantly ($P<0.05$) produced highest grain yield while Bida Local and Deko varieties produced lowest grain yield.

The mean values for number of panicles, panicle length and weight increased with increase in NPK rate (Table 5). Although the mean values (1.09, 41.11 cm and 43.7 g/plant for number of panicles, panicle length and weight, respectively) were highest with 400 kg/ha application but the mean values recorded with the application of 200 kg/ha NPK revealed no significant difference ($P>0.05$). On the other hand, grain weight and yield (25.3 kg/plant and 1.35 t/ha) were highest with 200 kg/ha NPK application. Plants that received no fertilizer significantly ($P<0.05$) had least performance with respect to all the yield and yield attributes.

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Table 5: Main effects of variety on number of panicle, panicle length, panicle weight, grain weight, grain yield

	No. of Panicle	Panicle length (cm)	Panicle weight (g/plant)	Grain weight (g/plant)	Grain yield (t/ha)
Variety					
Bida Local	1.00	54.48	26.9	15.92	0.849
CSR-01	1.04	37.27	46.1	25.40	1.355
Deko	1.14	24.39	25.7	16.47	0.878
KSV-8	1.09	41.83	37.3	22.16	1.182
SK-5912	1.00	30.78	56.5	34.91	1.862
$LSD_{0.05}$	ns	5.87	7.99	3.587	0.191
NPK rate (kg/ha)					
0	1.03	34.95	31.5	19.85	1.059
200	1.04	37.55	40.3	25.33	1.351
400	1.09	41.11	43.7	23.73	1.266
$LSD_{0.05}$	ns	4.55	6.2	2.78	0.148

Table 6: Interaction effect of variety and NPK rate on yield and yield components of sorghum

Variety	NPK rate (kg/ha)	No. of Panicle	Panicle Length (cm)	Panicle weight (g/plant)	Grain weight (g/plant)	Grain yield (t/ha)
Bida Local	0	1.00	50.33	22.9	13.61	0.726
	200	1.00	57.79	30.9	17.80	0.949
	400	1.00	55.32	26.8	16.34	0.871
CSR-01	0	1.00	32.31	37.4	24.22	1.292
	200	1.00	35.11	40.3	24.04	1.282
	400	1.13	44.38	60.7	27.95	1.491
Deko	0	1.10	23.34	20.2	13.03	0.695
	200	1.17	23.33	20.8	14.34	0.765
	400	1.14	26.48	36.2	22.03	1.115
KSV-8	0	1.03	37.96	30.8	20.56	1.097
	200	1.03	39.58	42.0	26.73	1.426
	400	1.20	47.94	39.2	19.17	1.023
SK-5912	0	1.00	29.01	46.4	27.85	1.485
	200	1.00	31.92	67.5	43.74	2.333
	400	1.00	31.41	55.7	33.16	1.768
$LSD_{0.05}$		ns	ns	13.8	6.21	0.331

Interaction effect of variety and fertilizer rates on yield and yield components of sorghum

Panicle weight, grain weight and yield were significantly influenced by the interaction of sorghum variety and NPK rates (Table 6). Highest panicle and grain yield were obtained in SK-5912 with the application of 200 kg/ha NPK. On the other hand, lowest panicle weight, grain weight and grain yield was recorded in Deko variety that received no fertilizer. Statistically there were no significant difference in the number of panicle and number of days to harvest (P>0.05) amongst the interaction of the varieties and fertilizer rates.

4. DISCUSSION

The variations in the phenology among the sorghum variety indicates that there are variations in their genetic make-up. It further confirms that the hybrids are early maturing varieties since they flowered and matured earlier than the local variety (Bida Local). It also implies that the genetic trait for early maturing in the hybrids are stable as there was no environmental influence on the trait. Early maturity in crops is a desired trait in order to have early yield and harvest with the corresponding avoidance of pests and disease prevalence as well as abiotic stress such as moisture. Early flowering (68 days) of the Improved Deko was in agreement with the report on the new sorghum variety as documented by ICRISAT (ICRISAT, 2022b).

Generally, the growth parameters established that the hybrids are short varieties compared to the Bida Local as the later variety recorded taller shoots and wider stems than the hybrids but produced higher number of leaves than all the hybrids. One of the desirable traits in breeding of cereal crops (which possess fibrous root system) is shortness in order to avoid lodging of the plants especially those that produce heavier panicles. This was confirmed by the yield and yield components recorded in this study. Panicle weight, grain weight and yield were higher in the hybrids (shorter varieties) than the Bida Local although the Bida Local produced longest panicles.

The progressive increase in plant height, number of leaves and stem girth with increasing rate of NPK application suggested that soil nitrogen, phosphorus and potassium concentrations must have been progressively enhanced, by the application of NPK, with their corresponding absorption and proper utilization for increased growth and development of the sorghum plants. Nitrogen is an important element that promotes vegetative growth in plants. Increase in nitrogen concentration usually enhances the luxurious growth of plants. Similar trend was reported on sorghum in hot to warm semi-arid low land plains and Northern Guinea Savannah of Nigeria by Gebremariam and Assefa (2015) and Muhammed *et al*. (2018), respectively.

However, the most vigorous plants at harvest recorded when the plants were treated with 400 kg/ha NPK could not culminate in highest grain yield rather the application of 200 kg/ha produced highest mean values for panicle length, weight and grain yield. This revealed that 200 kg/ha NPK application could be the optimum NPK rate for highest panicle and grain yield in the study area.

5. CONCLUSION

The study confirmed that the new varieties are early flowering and maturing sorghum varieties and can adapt to a humid tropical zone of Anambra state. Although the Bida Local performed better than the new varieties with respect to growth parameters but the new varieties produced heavier panicles and grains than the landrace, especially SK-5912, KSV-8 and CRV-01 especially when the plants received 200 kg/ha NPK 15:15:15. Hence, production of these new varieties with fertilizer amendment were recommended in the study area. Further studies on determination of appropriate fertilizer type, time of application and planting dates should also be given consideration.

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