Evaluation of Grain Yield, Yield Components and Genetic Parameters of Sorghum (Sorghum bicolor [L.] Moench) Varieties in Dutse, Nigeria

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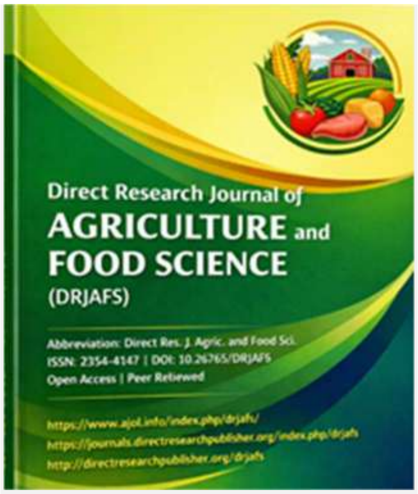
ABSTRACT

This study evaluated ten sorghum (Sorghum bicolor [L.] Moench) varieties for yield and yield-related traits under field conditions during the 2025 rainy season in Dutse, Jigawa State, Nigeria. The experiment was conducted to assess the extent of genetic variability among the varieties and identify superior genotypes adapted to the Sudan savanna agro-ecological zone. Data were collected on emergence, growth, phenological traits, yield components, pest and disease incidence, and grain yield. The results revealed significant variability among the sorghum varieties for traits like days to flowering, days to maturity, plant height, 1000 grain weight and grain yield, indicating strong genetic difference and variability. Early maturing varieties such as SAMSORG 52 exhibited shorter growth cycles, making them suitable for drought escape, while late maturing varieties such as SAMSORG 47 showed longer grain-filling periods and higher yield potential. SAMSORG 47, SAMSORG 48, and Fara-Fara consistently recorded superior yield performance. Heritability estimates indicated strong genetic control for phenological and morphological traits, while yield and some agronomic traits were influenced by environmental factors. The study confirms the presence of substantial genetic variability among sorghum genotypes and highlights the importance of selecting for stable and high-performing traits in breeding programmes. However, since the evaluation was conducted at a single location during one cropping season, environmental effects and genotype × environment interactions could not be adequately partitioned from genetic effects. Consequently, the estimates of genetic variability, heritability, and varietal performance should be interpreted with caution and validated through multi-location and multi-season trials before broad recommendations are made. Within the conditions of this study, SAMSORG 47, SAMSORG 48, and Fara-Fara emerged as the most promising varieties for further evaluation and potential cultivation in the Sudan savanna agro-ecological zone.

***Keywords**: Sorghum, genetic variability, yield performance, heritability, Sudan savanna, varietal evaluation*



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INTRODUCTION

Sorghum (*Sorghum bicolor* [L.] Moench) is a self-pollinating, diploid cereal crop belonging to the Poaceae (Gramineae) family. Globally, it ranks as the fifth most important cereal crop after maize, rice, wheat, and barley. It is a C_4 plant with high photosynthetic efficiency and productivity (Tari *et al*., 2013). Africa remains the leading region in sorghum production, contributing approximately 46% of global output, followed by the Americas with about 35% (FAO, 2024). The crop is cultivated in over 110 countries, with major production from the United States, Nigeria, and Mexico. Sorghum is primarily utilized for human consumption (47.5%) and animal feed (34.7%), while the remainder is used for industrial purposes and seed (FAO, 2024). Nigeria is one of the world's leading producers of sorghum, with production estimated at approximately 6.8 million tons in 2022 and 6.9 million tons in the 2025. The crop is predominantly cultivated in the northern regions, spanning the Sudan and Sahel savanna zones. These areas are characterized by low rainfall, high temperatures, and well-drained sandy loam soils, which are suitable for sorghum production. Sorghum is widely recognized for its adaptability to diverse environmental conditions and its tolerance to both biotic and abiotic stresses (Machado and Paulsen, 2001; Tari *et al*., 2013; Huang *et al*. 2018; Zhang *et al*., 2019). Its versatility arises from its multiple uses, including human food, livestock feed, biofuel production, and forage. Nutritionally, sorghum grain contains approximately 70–80% carbohydrates, 11–13% protein, 2–5% fat, 1–3% fiber, and 1–2% ash (Dicko *et al*., 2006). These attributes, combined with its resilience, have positioned sorghum as a strategic crop for addressing global food security challenges. Sorghum is a staple crop for farmers in northern Nigeria, providing food, fodder, and income for rural households (FAO, 2022). Jigawa State is among the major sorghum-producing regions in the country. Although several improved sorghum varieties have been developed for specific agro-ecological zones (Ajeigbe *et al*., 2018), productivity remains low. This low productivity is largely attributed to the continued use of traditional landraces, which are characterized by poor stress tolerance, long maturity periods, tall plant stature, low responsiveness to improved agronomic practices, and low yield potential (NASC, 2021). Furthermore, although improved high-yielding and drought-tolerant varieties are available, their performance under the specific agro-climatic conditions of Dutse has not been adequately evaluated (Olanrewaju *et al*., 2020). In addition, extension recommendations often adopt a generalized approach without sufficient local validation, despite the unique environmental conditions of Dutse, including sandy soils and short rainy seasons (NASC, 2023).

Sorghum is a critical crop for farmers in Dutse, Jigawa State, due to its adaptability to hot and dry conditions. However, many farmers still cultivate low-yielding traditional varieties that produce significantly less than improved cultivars. A major challenge is the wide gap between potential yield and actual farm yield. This study aims to evaluate different sorghum varieties under local conditions to identify those with superior yield performance, early maturity, and better adaptation. The use of genetic parameters such as variability, heritability, and genetic advance will provide insight into the potential for genetic improvement and selection efficiency. The findings from this study will help identify high-performing varieties suitable for the Sudan Savanna zone. This will enable farmers to achieve higher yields, improve food security, and increase income without requiring additional inputs. Furthermore, the results will provide valuable information for breeders and policymakers in developing and promoting location-specific sorghum varieties.

The objectives of this study are to:

i. To evaluate yield and yield related traits of sorghum varieties and identify those with high yield and good adaptation to local conditions.
ii. To estimate genetic variability and broad sense heritability of yield and related traits.
iii. To recommend high yielding and agronomically superior sorghum varieties for farmers and breeding programs.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm, Faculty of Agriculture, Federal University Dutse, Jigawa State, Nigeria. Dutse is located within the Sudan Savanna agro-ecological zone in north western Nigeria (11° 70′ N, 9° 34′ E; 460 m above sea level). The study was carried out during the 2025 rainy season. The physical and chemical properties of the soils of the study area are as presented in Table 1 below.

Table 1: Physical and chemical properties of the soil in the study area

Soil property	
Clay	26%
Silt	14%
Sand	60%
Textural Class	**Sandy clay loam**
pH (H_2O)	8.2
Ph (KCL2)	7.2
Electrical conductivity (dS/m)	0.51
Organic Carbon (g/kg)	9.74
Organic Matter (g/kg)	13.87
Total Nitrogen (g/kg)	0.75
Available P (mg/kg)	3.82
Exchangeable Bases (cmol/kg)	
Ca	1.88
Mg	0.78
K	0.17
Na	0.57
SEB (cmol/kg)	3.40

Source: Onokebhagbe *et al*. (2023)

The area is characterized by a unimodal rainfall pattern (May–October), with an average annual rainfall ranging from 600 to 1000 mm. The soils are predominantly sandy clay loam with moderate fertility. Ten (10) sorghum (*Sorghum bicolor* [L.] Moench) varieties were used in this study. Eight improved varieties were obtained from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), while two local varieties were sourced from farmers within the study area.

The experiment consisted of ten sorghum varieties as described in Table 2. It was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot has 4 rows of 3m each, with inter-row spacing of 75cm and intra-row spacing of 50cm. A total of 30 plots (10 varieties × 3 replications) were established. A buffer zone of 2m was maintained between replications, and 0.75m between plots to minimize border effects. The land was cleared, ploughed, and harrowed to achieve a fine tilth. Ridges were constructed to improve drainage and

Table 2: Sorghum Varieties and their Characteristics

Variety	Maturity (days)	Potential Yield (t/ha)	Description	Recommended Region
Fara-Fara	Medium (95–100)	2.5–3.5	Tall, white-seeded	Sudan & Sahel Savanna
SAMSORG 45	Early (80–95)	3.5–4.0	Medium height, white seed	Savanna zones
SAMSORG 46	Early (81–94)	3.0–3.5	Medium height, white seed	Savanna zones
SAMSORG 47	Early (80–95)	4.8	Medium height, bold yellow grain	Sudan & N. Guinea Savanna
SAMSORG 48	Early (85–90)	4.7	Medium-tall, yellow seed	Sudan & N. Guinea Savanna
SAMSORG 49	Early (85–90)	2.8	Medium height	Sudan & Sahel Savanna
SAMSORG 52	Early (85–90)	3.5	Dwarf, high iron, drought-tolerant	Sudan & N. Guinea Savanna
SAMSORG 53	Medium (95–100)	3.7	Semi-dwarf, high biomass	Sudan & N. Guinea Savanna
SAMSORG 54	Medium (95–110)	3.8	Semi-dwarf, compact panicle	Sudan & N. Guinea Savanna
Kaura	Late (100–110)	2.0–3.0	Tall, red-seeded	Sudan Savanna

aeration. Seeds were treated with a systemic fungicide/insecticide (Seed Care) to protect against soil-borne pathogens and early pest attacks, ensuring uniform germination. Three to five seeds were sown per hole at a depth of approximately 2.5cm, using a spacing of 75cm between rows and 50cm within rows and thinned down at three weeks after planting (WAP) to maintain two plants per stand. NPK (15:15:15) fertilizer at the rate of 200 kg/ha through spot application was applied at three weeks after sowing, followed by urea at six weeks after sowing, supplying 64 kg N, 30 kg P_2O_5, and 30 kg K_2O per hectare. Manual weeding was carried out at 3, 6, and 10 WAP to reduce weed competition. Regular field scouting was conducted, and appropriate control measures were applied when necessary.

Harvesting was carried out at physiological maturity. Panicles were either cut directly or after cutting the whole plant, depending on plant height. Harvested panicles were dried to 13–15% moisture content and manually threshed. Data were collected from five randomly selected and tagged plants per plot on the following agronomic and yield parameters: number of plants at emergence, leaf area measured at 9 WAP estimated using the following formula:

〖"Leaf Area (cm" 〗^2 ")"=L×W×K.

Where K is a correction (shape) factor = 0.75

L = Length, W = Width

Days to 50% flowering, plant height (cm), days to maturity and number of plants at maturity, panicle length (cm), panicle width (cm), 1000-grain weight (g) and grain yield (kg ha^{-1}) were also estimated according to Izge et al. (2007). Incidence of pests and diseases was estimated applying the following formula: Incidence (%) = Number of infected or infested plants/Total number of plants assessed x 100. Data collected were subjected to Analysis of Variance (ANOVA) using SAS statistical software. Treatment means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Genetic parameters were estimated as follows:

Genotypic variance (σ^2 g) = $\frac{MSg-MSe}{r}$

MSg = Mean sum of squares for genotypes.
MSe = Mean sum of squares for error.
r = Number of replications

Phenotypic Variance (σ^2 p) = $\sigma^2 g + \sigma^2 e$

Where, $\sigma 2\,g$ = genotypic variance, and $\sigma 2e =$ environmental variance

Genotypic Coefficient of Variation (GCV) $= \frac{\sqrt{\sigma 2\,g}}{x}$ x 100%

Phenotypic Coefficient of Variation (PCV) = $\frac{\sqrt{\sigma 2\,p}}{x}$ x 100%

Where, $\sigma 2\,p$ = total phenotypic variance and x = population mean

Broad-Sense Heritability (H^2) **=** $\frac{\sigma 2\,g}{\sigma 2\,p}$

Where, $\sigma 2\,g$ = genotypic variance
$\sigma 2\,p$ = phenotypic variance

Genetic Advance (GA) = K x σ^2 p x H^2

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) revealed significant differences among sorghum varieties for several evaluated traits (Table 2), indicating the presence of genetic variability. The presence of significant variation among varieties in Table 3 suggests high genetic variability, which is fundamental for any crop improvement program. Genetic variability provides the raw material for selection; without it, breeding progress becomes limited. In sorghum, such variability is expected due to its wide adaptation to diverse agro-ecological zones and its naturally cross-pollinated nature at low levels. Significant differences in

Table 3: Analysis of variance showing mean squares for yield and related yield components

SV	DF	NPE	DFF	PHT	NPM	LAR	PNL	PNW	GYD	TGW	SHS	DWM	FAW	DMT
Treatments	9	46.13*	141.13*	11005.09*	43.84*	8637.72	158.58	7.67	686703.8*	167.33*	1401.35*	2.83	384.16	141.29*
Blocks	2	2.70	40.53	83.60	1.90	18886.38	123.81	13.86	91909.09	11.37	358.16	2.31	1330.88	29.633
Error	18	310.6	18.57	1035.09	15.38	6832.70	161.75	6.11	383098.68	26.83	316.42	3.59	856.24	17.45

NPE = Number of plants at emergence, DFF = Days to 50% flowering, PHT = Plant height, NPM = Number of plants at maturity, LAR =Leaf area, PNL = Panicle length, PNW = Panicle weight, GYD = Grain yield, TGW = 1000 grain weight, SHS = Sorghum head smut, DWM = Downy mildew incidence, FAW = Fall Armyworm incidence, DMT = Days to maturity

Table 4: Mean performance of sorghum varieties for yield and yield components

Treatments	NPE	LAR	PHT	DFF	NPM	DMT	PNL	PNW	GYD	TGW	FAW	DWM	SHS
FARA-FARA	24.00a	465	286.30a	78.00c	20.67a	115.00b-d	28.6	14.79	1303.70c	28.18bc	12.50	1.39	11.11
SAMSORG 45	14.00b	405	182.17c-e	72.00cd	12.00b	109.00de	26.4	18.87	651.85f	41.14a	27.50	0.00	30.55
SAMSORG 46	14.67b	417	206.87b-d	72.00cd	13.33b	109.00de	27.0	17.34	918.52de	44.78a	28.57	0.00	41.66
SAMSORG 47	20.00ab	484	181.95c-e	88.67a	17.67ab	127.00a	43.7	18.16	2251.85a	40.16a	27.47	2.78	47.22
SAMSORG 48	24.00a	378	246.00ab	80.33b	21.67a	120.00ab	30.5	15.40	1659.25b	37.58ab	5.55	1.39	65.27
SAMSORG 49	24.00a	362	152.05de	70.67d	22.67a	110.33c-e	19.68	13.95	888.89de	28.30bc	18.05	0.00	9.72
SAMSORG 52	22.67a	298	87.95f	68.33d	20.67a	105.33e	24.4	16.23	859.18de	28.52bc	33.33	0.00	4.14
SAMSORG 53	23.67a	421	127.58ef	83.67ab	22.00a	119.00b	23.0	15.35	859.18de	29.01bc	18.05	0.00	8.33
SAMSORG 54	23.00a	360	132.73ef	80.00b	22.33a	117.00bc	28.6	17.79	1274.07d	22.01c	45.83	0.00	0.00
KAURA	24.00a	411	230.06a-c	85.00ab	21.00a	122.00ab	32.0	15.23	1037.03de	39.20a	23.44	0.00	29.16
S.E ±	**3.392**	**67.5**	**18.55**	**3.519**	**3.202**	**3.411**	**10.38**	**2.019**	**505.370**	**4.229**	**23.892**	**1.10**	**14.524**

Means followed by the same letter within column are not significantly different at 5% level of probability.
NPE = Number of plants at emergence, DFF = Days to 50% flowering, PHT = Plant height, NPM = Number of plants at maturity, LAR =Leaf area, PNL = Panicle length, PNW = Panicle weight, GYD = Grain yield, TGW = 1000 grain weight, SHS = Sorghum head smut, DWM = Downy mildew incidence, FAW = Fall Armyworm incidence, DMT = Days to maturity

agronomic traits also imply that environmental effects alone cannot explain the observed variation, meaning that genetic factors play a major role. This is important because it allows breeders to identify superior genotypes with desirable traits such as higher grain yield, drought tolerance, or early maturity for direct release or use as parents in hybridization.

Furthermore, the presence of variability suggests that agronomic traits evaluated are likely to have moderate to high heritability, making selection more effective. Similar findings have been reported in sorghum and other cereals, where results revealed significant genotypic effects for yield and related agronomic traits, confirming the usefulness of variability in breeding programs (Baloch et al., 2015; Abduselam et al., 2018). In addition, genetic variability among sorghum genotypes has been widely reported as essential for improving productivity under stress environments, particularly drought prone savanna regions. Studies have shown that exploiting this variability leads to development of improved varieties with better adaptation and yield stability (Ajeigbe et al., 2018; Abreha et al., 2021). Overall, the significant ANOVA results confirm the existence of exploitable genetic variability. Our result is however contestable and may need validation as it was conducted in only a location and in one year. The results from Table 4 clearly demonstrate meaningful genetic differences in emergence, vegetative growth, and plant architecture among sorghum varieties, which are key traits influencing establishment, productivity, and adaptability. Higher emergence in varieties such as Fara-Fara, SAMSORG 48, 49, 52, 53, and Kaura suggests strong seed vigour and better physiological quality, which enhances rapid and uniform seedling establishment. Good emergence is often associated with genetic potential for germination, seedling robustness, and tolerance to early-season stress conditions, especially in drought-prone savanna environments. This agrees with findings that seed vigor is a major determinant of field performance and crop stand establishment in cereals (Igartua et al., 1994; Blum, 2004). Poor emergence in SAMSORG 45 and 46 may indicate lower seed quality or weaker genetic adaptability, leading to reduced field establishment and potentially lower yield. Although leaf area differences were not statistically significant, the relatively larger leaf surfaces observed in SAMSORG 47 and Fara-Fara may still have biological importance. Larger leaf area can improve light interception and photosynthetic assimilation, thereby enhancing biomass production under favorable conditions. However, non-significant variation suggests that leaf expansion may be more environmentally influenced than genetically controlled in the tested environment, as also noted in physiological studies of sorghum under field conditions (Machado & Paulsen, 2001). The significant variation in plant height confirms strong genetic control over this trait, consistent with earlier genetic studies in sorghum and other cereals (Falconer & Mackay, 1996; Baloch et al., 2015). Tall varieties such as Fara-Fara (286.30 cm), SAMSORG 48 (246.00 cm), and Kaura (230.06 cm) are likely to have greater assimilate accumulation and biomass production, which can contribute to higher fodder yield and potentially grain yield under good management. However, excessive plant height is often associated with lodging susceptibility, especially under high wind or rainfall conditions.

Conversely, shorter varieties such as SAMSORG 52 (87.95 cm) may exhibit better lodging resistance and improved harvest stability, making them suitable for mechanized farming or high-input systems.

However, reduced height may also limit biomass accumulation and yield potential, depending on the genotype. The observed variation highlights the importance of selection for balanced ideotypes, where breeders aim to combine: high emergence and seed vigor (for good establishment), optimal leaf area (for efficient photosynthesis), and moderate plant height (for lodging resistance and yield stability). Such trait combinations are essential for improving sorghum productivity in Sudan savanna agro-ecologies, where drought and terminal stress are common. Significant differences in days to flowering, days to maturity, and plant survival at maturity indicate the presence of substantial genetic variation among the sorghum varieties. Early-flowering genotypes such as SAMSORG 52 (68.33 days) and SAMSORG 49 are particularly advantageous in drought-prone environments, as they can complete their life cycle before the onset of terminal drought stress.

Early maturity is widely recognized as a key adaptive trait in sorghum, allowing crops to escape drought and heat stress during grain filling, thereby improving yield stability under rainfed conditions (Blum, 2004; Abreha et al., 2021). In contrast, late-maturing varieties such as SAMSORG 47 (127 days) and Kaura benefit from a longer vegetative and grain-filling period, which often enhances assimilate accumulation and biomass production under adequate moisture conditions. However, such genotypes may be more vulnerable to end-of-season drought stress, especially in the Sudan savanna ecology (Machado & Paulsen, 2001). High plant survival (20–22 plants) across most varieties suggests good field establishment and adaptation, while lower survival in SAMSORG 45 and 46 may reflect reduced stress tolerance or weaker seedling vigor. Seedling establishment is strongly linked to genetic quality and environmental adaptability, particularly in cereals grown under variable rainfall conditions (Igartua et al., 1994). Although panicle length and width were not significantly different, numerical variation (e.g., longer panicles in SAMSORG 47) may still be agronomically important, as panicle architecture is often associated with grain number and sink capacity, which ultimately influences yield potential. Grain yield differences were statistically significant, with clear numerical trends observed, with SAMSORG 47 producing the highest yield (2251.85 kg ha^{-1}), followed by SAMSORG 48 and Fara-Fara. The presence of significance difference could be attributed to inherent genetic possibilities and may be to variations in soil fertility and to some other factors that are commonly reported in field trials of sorghum (Ajeigbe et al., 2018; Abreha et al., 2021). On the other hand, the highly significant variation in 1000-grain weight could mean the existence of strong genetic control and relative stability of this trait. Despite the promising results obtained, confirmation through multi-environment testing is required, as the present study was conducted in a single year and location. This limitation restricts the accurate partitioning of environmental variance from genotype × environment interactions, thereby affecting the precision of the estimated genetic parameters. Consequently, the results should be regarded as preliminary until validated across diverse environments and seasons. Genotypes such as SAMSORG 46 (44.78 g), SAMSORG 45 (41.14 g), and Kaura (39.20 g) demonstrated superior grain-filling ability. Thousand-grain weight is widely considered a stable yield component and an effective selection criterion in cereal breeding due to its moderate to high heritability (Falconer & Mackay, 1996; Baloch et al., 2015). For pest and disease response, non-significant differences in fall armyworm and downy mildew incidence suggest that most varieties exhibited comparable baseline tolerance, although numerical differences indicate potential variability in resistance. Notably, SAMSORG 48 showed lower fall armyworm incidence, suggesting possible partial resistance, while SAMSORG 54 appeared more susceptible. However, sorghum head smut showed significant variation among genotypes, indicating strong genetic control of resistance. The complete resistance observed in SAMSORG 54 and high susceptibility in SAMSORG 48 highlight the importance of host plant resistance as a key strategy in integrated disease management. Genetic resistance to sorghum diseases has long been identified as the most sustainable and cost-effective control method in breeding programs (Sharma, 1993; Afolayan et al., 2020). The estimates of genetic parameters presented in (Table 5) show high heritability coupled with high genetic advance (GA) for days to flowering, days to maturity, plant height, 1000-grain weight, and head smut resistance, indicating that these traits are largely controlled by additive gene action. This implies that phenotypic selection for these traits would be highly effective in early generations because the observed variation is reliably transmitted to the next generation. Such traits are typically less influenced by environmental variation and therefore respond well to direct selection pressure in breeding programs. Similar conclusions have been widely reported in sorghum and other cereals, where high heritability and genetic advance for phenological and morphological traits indicate strong genetic control and breeding potential (Baloch et al., 2015; Falconer & Mackay, 1996). The high heritability observed for days to flowering and maturity is particularly important in sorghum improvement, as these traits determine drought escape ability and adaptation to different agro-ecological zones. Early and uniform flowering is a key selection criterion in dryland breeding because it reduces exposure to terminal drought stress and stabilizes yield (Blum, 2004; Abreha et al., 2021). Similarly, high heritability for plant height and 1000-grain weight suggests that these yield components

Table 5: Estimates of means and genetic parameters in sorghum

Trait		**Mean**	**MSv**	**MSe**	**σ^2g**	**σ^2p**	**GCV (%)**	**PCV (%)**
No. of Plants at Emergence	21.40	38.236	17.256	6.99	12.25	19.41	21.40	57.52
Leaf Area	399.99	10501.11	6832.70	3502.79	7335.49	20.66	22.92	48.43
Days to 50% Flowering	77.87	122.84	18.57	34.36	42.93	23.23	25.92	80.17
Plant Height	183.37	9019.37	1035.09	8728.66	10363.76	17.55	20.67	84.19
Days to Maturity	115.37	122.84	18.57	14.58	18.03	3.62	4.18	80.91
No. of Plants at Maturity	19.40	36.21	15.38	7.61	12.99	20.22	23.22	58.99
Panicle Length	30.78	8.80	6.11	2.23	6.11	17.00	19.00	36.52
Panicle Weight	16.41	8.80	6.11	2.63	6.11	15.07	21.07	46.80
Grain Yield	1170.35	686703.81	383098.68	303605.14	686703.82	19.00	22.00	47.99
1000 Grain Weight	33.95	138.97	26.83	812.63	1067.46	19.53	24.00	75.99
Fall Army Worm Incidence	24.03	2.73	3.60	1.13	3.60	121.77	341.64	28.42
Downy Mildew Incidence	0.56	1.21	1.90	1.21	1.90	341.64	341.64	31.71
Sorghum Head Smut Incidence	24.72	1211.68	316.42	895.26	1211.68	71.96	71.96	70.06

Note: σ^2g, σ^2p, GCV (%), PCV (%), H^2 (%), GA means Genotypic Variance, Phenotypic Variance, Genotypic Coefficient of Variation, Phenotypic Coefficient of Variation, Broad-Sense Heritability, and Genetic Advance respectively

are genetically stable and can be improved through selection without strong environmental interference. Moderate heritability values observed for grain yield, leaf area, and panicle traits indicate that these traits are influenced by both genetic and environmental factors. Grain yield, in particular, is a complex quantitative trait governed by multiple genes and strong genotype × environment (G×E) interactions, making direct selection less efficient compared to selection for its component traits. This agrees with earlier findings that yield is often less heritable than its contributing traits and is highly environment-dependent (Machado & Paulsen, 2001; Ajeigbe et al., 2018). Therefore, indirect selection through more stable components such as grain weight and flowering time is often recommended. Traits exhibiting high genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), particularly pest and disease resistance traits, indicate substantial variability within the germplasm. However, the noticeable gap between GCV and PCV suggests that environmental factors significantly influence their expression. This means that although genetic variability exists, expression of resistance is unstable across environments, necessitating multi-location and multi-season testing to accurately identify stable resistant genotypes. This is consistent with findings in plant pathology and breeding studies, where disease resistance often shows strong environmental modulation and requires rigorous field validation (Sharma, 1993; Afolayan et al., 2020). Overall, the results indicate that morphological and phenological traits such as flowering time, maturity, plant height, and grain weight exhibited relatively high heritability and genetic advance under the conditions of the study, suggesting that they may respond well to selection. However, because the evaluation was conducted at only one location and within a single growing season, environmental effects could not be adequately separated from genotype × environment (G×E) interactions. Consequently, the estimated genetic parameters may not fully reflect the true genetic potential of the genotypes across diverse environments. Validation through multi-location and multi-season trials is therefore necessary before making definitive breeding decisions. Similarly, the lower heritability and genetic advance observed for grain yield and resistance traits suggest that these characters are more strongly influenced by environmental factors. Improvement of such traits will require evaluation across multiple environments and years, combined with selection based on yield components, stability analysis, and appropriate pest management strategies to identify genotypes with consistent performance.

Conclusion

This study evaluated ten sorghum (Sorghum bicolor [L.] Moench) varieties for yield and yield-related traits under the agro-ecological conditions of Dutse, Jigawa State, Nigeria, during the 2025 rainy season. The results revealed considerable genetic variability among the evaluated genotypes, particularly for phenological traits (days to flowering and maturity), plant height, 1000-grain weight, and grain yield. Early-maturing varieties, especially SAMSORG 52, demonstrated potential adaptation to drought-prone conditions through early completion of their life cycle, while late-maturing varieties such as SAMSORG 47 exhibited relatively higher yield potential, likely due to extended grain-filling duration. There were statistically significant differences in grain yield among the varieties, and the superior performance of SAMSORG 47, SAMSORG 48, and Fara-Fara suggests that these genotypes possess desirable agronomic characteristics under the environmental conditions of the study area. The relatively high heritability and genetic advance observed for flowering time, maturity, plant height, and 1000-grain weight indicate that these traits could serve as useful selection criteria in sorghum improvement programs. However, the findings should be interpreted with caution because the experiment was conducted at only one location and during a single cropping season. Consequently, environmental effects and genotype × environment interactions could not be adequately separated from genetic effects, and the estimated genetic parameters may not fully represent varietal performance across diverse environments. Therefore, the observed superiority of some genotypes and the estimated heritability values should be regarded as preliminary and require validation through multi-location and multi-season evaluations before broad recommendations can be made. Nevertheless, the study demonstrates the existence of useful genetic variability within the evaluated germplasm that can be exploited in future sorghum breeding and varietal development programs.

Recommendations

Based on the findings of this study, the promising performance of SAMSORG 47, SAMSORG 48, Fara-Fara, and SAMSORG 52 warrants further evaluation across multiple locations and seasons to determine their yield stability, adaptability, and suitability for wider cultivation. Breeding programmes should place greater emphasis on traits such as flowering time, maturity, plant height, and 1000-grain weight, as these traits exhibited relatively high heritability and genetic advance and may therefore respond effectively to selection. Since grain yield and other environmentally sensitive traits are strongly influenced by environmental conditions, they should be evaluated through replicated multi-environment trials to obtain more reliable estimates of genetic parameters and genotype performance. Future research should also investigate genotype × environment interactions to identify varieties with either broad or specific adaptation to different agro-ecological zones. Additional studies focusing on panicle characteristics, stress tolerance, disease resistance, and yield component traits are necessary to enhance the efficiency of sorghum improvement programs. Farmers in Dutse and similar Sudan Savanna environments may consider testing the better-performing varieties identified in this study on a limited scale; however, large-scale adoption should be deferred until their performance has been confirmed through multi-location and multi-year evaluations. Furthermore, extension agencies and research institutions should collaborate in conducting on-farm participatory trials to validate the performance of promising varieties under farmers' field conditions and facilitate their eventual dissemination.

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