Natural Resources, 2026, 17(1), 59-73
https://www.scirp.org/journal/nr
ISSN Online: 2158-7086
ISSN Print: 2158-706X

Evaluation of the Agronomic Performance of Different Sorghum Varieties at the Inran Experimental Station of Bengou (Gaya Department)

Yahaya Aissata Mamadou[1], Hamma Kailou Illiassou[2], Ardaly Abdou Ousseini[2], Zakari Moussa Ousmane[2]

[1]Department of Rainfed Crops, National Institute of Agronomic Research of Niger, INRAN, Niamey, Niger
[2]Department of Crops Production, Faculty of Agronomy, University Abdou Moumouni of Niamey, UAM, Niamey, Niger
Email: intaaoudi@yahoo.fr, illiassou@gmail.com, ardalyhousseini@yahoo.fr, o.zakari@gmail.com

How to cite this paper: Mamadou, Y.A., Illiassou, H.K., Ousseini, A.A. and Ousmane, Z.M. (2026) Evaluation of the Agronomic Performance of Different Sorghum Varieties at the Inran Experimental Station of Bengou (Gaya Department). *Natural Resources*, **17**, 59-73.
https://doi.org/10.4236/nr.2026.171004

Received: December 26, 2025
Accepted: January 23, 2026
Published: January 26, 2026

Abstract

In Niger, sorghum (*Sorghum bicolor* L. Moench) ranking second most widely cultivated cereal after millet plays a dominant role in agricultural production systems. It is a staple food for millions of people but productivity levels remain relatively low in smallholder farming areas. The study was conducted at the INRAN experimental station in Bengou (3˚33′25″ and 11˚59′44″) and evaluated the agronomic performance of twenty-four (24) sorghum varieties from different West African countries in order to identify the best adapted varieties to the agro-ecological conditions of Niger and to evaluate the response of different varieties to major production constraints, including low soil fertility, pest pressure, diseases and low rainfall. The trial was conducted using a randomized incomplete block design with three replications. The analysis showed that some varieties exhibited better productivity than the control. Phenological results revealed that several varieties were significantly earlier maturing than the control. In terms of disease resistance, the majority of varieties proved highly resistant to anthracnose and sorghum stripe. The varieties TEMOIN 1, MDK, and BC110-19 exhibited the greatest heights, and TEMOIN 1 stood out for its high dry biomass, highlighting its forage potential. Some varieties, such as MDK, SASSILON, ICSB 176003, 014-SB-EPDU-1004, and SOUBATIMI, obtained the best grain yields, exceeding those of the control. These results highlight the existing agronomic diversity between varieties and their potential to meet production needs under Niger's agro-ecological conditions.

Keywords

Sorghum, Adaptability, Agronomic Performance, Agro-Ecological Zones, Gaya

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is a major cereal crop cultivated both for its grain, used for human consumption and for its residues, used as animal feed [1]. Because of its high ecological plasticity, sorghum is able to adapt to a wide range of agro-climatic conditions, both in tropical and temperate regions, making it a strategic crop face of climate risks.

Africa is recognized to be a center of domestication of several cereals, including sorghum, which is the second most important cereal after maize in terms of cultivated area (22% of global cereal acreage) according to [2]. In 2022, sorghum FAO global production was estimated at 57.58 million tons with a harvest area of 40.76 million hectares, placing it fifth among the world's most produced cereals, after maize, wheat, rice, and barley [3]. In developed countries, sorghum is primarily used for animal feed, while in Africa and India, it is a staple food for millions of people [4].

Despite significant progress in sorghum varietal improvement, both through conventional methods (mass selection, pedigree selection, mutagenesis) and the introduction of new improved varieties, productivity levels remain relatively low in smallholder farming areas. Yields rarely exceed 1.5 t ha^{-1} in many production zones, which does not adequately meet the growing food needs of the population [5].

In Niger, sorghum plays a dominant role in agricultural production systems. In 2019, it was cultivated on approximately 3.8 million hectares, representing 20% of the cultivated area ranking as the second most widely cultivated cereal after millet [1]. However, the national average yield which is very low (506 kg ha^{-1} in 2019) remains below the estimated global average of 1,445 kg ha^{-1} for the same year [1]. According to [3], national production of sorghum was approximately 2.10 million tons from a harvested area of 3.78 million hectares. This low productivity is mainly due to several major constraints, including low soil fertility, pest and disease pressure, and the variability and scarcity of rainfall.

Since 1970s, significant efforts have been made by breeding programs in West Africa, with a particular focus on improving intermediate sorghum varieties, especially the Guinea-Caudatum type, to increase their yield potential and their adaptation to local agro-ecological conditions [6]. In this context, the agro-morphological and agronomic evaluation of sorghum varieties from different agro-ecological zones appears to be a relevant approach for identifying high-performing genotypes well-suited to the production conditions of Niger, particularly in Dosso region (13˚02′46″N, 3˚11′50″E) in the Southwest, which is highly exposed to the effects of climate change.

The overall objective of this study is to evaluate the agronomic performance of various sorghum varieties originating from different West African countries in order to identify varieties that are best adapted to the agro-ecological conditions of Niger. Specific objectives were to identify high-performing sorghum varieties in terms of grain yield, which are likely to contribute to improved food security and to evaluate the response of different varieties to major production constraints, including low soil fertility, pest pressure, diseases and low rainfall.

2. Materials and Methods

The study was conducted at the INRAN experimental station in Bengou (Dosso Region, Gaya Department; 3.45˚E longitude and 11.88˚N latitude). Bengou is located at 3˚33′25″E longitude and 11˚59′44″N latitude, with an average altitude of 172 m. Bengou lies in the Sudanian zone with a unimodal rainfall regime (June–October), annual rainfall of 800 mm - 900 mm, peak precipitation in August, and mean temperatures of 24˚C - 35˚C. Soils are ferruginous tropical soils, sandy-loam, well-drained, slightly acidic to neutral, and low to moderately fertile. The station was established in 1974 as a research site dedicated to the Sudanian zone, characterized by an average annual rainfall ranging from 800 to 900 mm. During the period of the experiment, total cumulative rainfall recorded at Gaya was approximately 820 mm - 830 mm, which is within the normal range for the agro-ecological zone. The plant material used consists of twenty-four (24) sorghum varieties coming from different NARs and international research institutions, including one local variety used as control (**Table 1**).

Table 1. List of varieties used.

Obtention	Variety	
Senegal	ISRA-S-756-27	1
Senegal	ISRA-S-754-81	2
Senegal	ISRA-S-756-34	3
Senegal	ISRA-S-754-79	4
Mali	SASSILON	5
Mali	BC113-05	6
Mali	BC110-19	7
Mali	014-SB-EPDU-1004	8
Mali	06-SB-F5DT-15	9
Mali	CS21-243	10
Burkina	SARIASO 14	11
Burkina	ICSB 176008	12
Burkina	ICSB 176003	13
Burkina	SARIASO 16	14
Togo	ITRASV221070	15

Continued

Togo	ITRASV2211084	16
Togo	ITRASV221107	17
Niger	MDK	18
Niger	TEMOIN 1 (Koussou Boggou)	19
ICRISAT	ICSV 1460016	20
ICRISAT	ICSV 206091	21
ICRISAT	SOUBATIMI	22
ICRISAT	ICSV 206079	23
ICRISAT	ICSV 166001	24

The trial was conducted using a randomized incomplete block design with three replications. Each replication comprised five subblocks of five varieties. Sowing was carried out in hills, with a spacing of 0.4 m between hills and 0.8 m between rows. As one of the varieties originating from Togo did not germinate, the evaluation ultimately included 24 varieties.

The phytosanitary and agronomic assessment was carried out by assigning severity scores based on the estimated percentage of leaf area affected by diseases and pests.

The severity of disease attacks was rated on a scale of 0 to 5, where 0 corresponds to the absence of symptoms (0% of leaf area infected), 1 to a highly resistant variety (1% - 10% of leaf area infected), 2 to a resistant variety (11% - 25% of leaf area infected), 3 to a moderately susceptible variety (26% - 50% of leaf area infected), 4 to a susceptible variety (51% - 75% of leaf area infected), and 5 to a highly susceptible variety (>75% of leaf area infected).

Data collection involved randomly selected samples from the center rows of each plot to minimize edge effects and inter-varietal competition. A total of thirteen (13) agro-morphological and phytosanitary variables were measured to assess the agronomic performance of the sorghum varieties. These variables were selected as part of the process of identifying the highest-performing varieties best adapted to the agro-ecological conditions of the study area.

The collected data were entered into an Excel spreadsheet. This software was also used to create tables and graphs using means and standard deviations. The different variations were evaluated by determining, for each variable, the mean, the coefficient of variation, and the observed probability. One variety originating from Togo failed to germinate in all experimental units. Consequently, this genotype was excluded from data collection and statistical analysis. The trial was therefore analyzed on the basis of twenty-four (24) varieties instead of the initially planned twenty-five (25). Because the missing variety occurred systematically across all replications, it did not introduce imbalance among treatments within blocks. The randomized incomplete block design was thus maintained, and the analysis of variance (ANOVA) was performed considering only the effectively established varieties. Mean comparisons were conducted on the reduced dataset using the Bonferroni test at the 5% significance level.

3. Results

3.1. Phenological Parameters

The results for the phenological parameters (flowering date and date of 50% flowering) revealed significant differences between the varieties ($P < 0.001$). Analysis of variance of the flowering data indicated that the earliest varieties were SARIASO 16, ITRASV2211084, ICSB 176003, ICSV 1460016, and SARIASO 14, while the latest varieties were BC110-19, ICSV 166001, MDK, CS21-243, and BC113-05. A cycle length of 23 days was observed between the earliest variety (SARIASO 16) and the latest variety (BC110-19). For the 50% flowering date parameter, the number of days varies from 75.66 to 97 days. The analysis showed that the earliest varieties were SARIASO 16, ICSV 1460016, ICSB 176003, SARIASO 14, and ITRASV2211084, while the latest varieties were BC110-19, ICSV 166001, MDK, CS21-243, and ISRA-S-754-81. A difference of 21 days in the flowering cycle was also observed between the earliest variety (SARIASO 16) and the latest variety (BC110-19) (**Table 2**).

Table 2. Flowering parameters analysis.

Varieties	DFL	D50% FL
BC110-19	94 ± 1^{a}	97 ± 2^{a}
ICSV 166001	$94 \pm 1_{a}$	97 ± 2^{a}
MDK	93 ± 1^{a}	97 ± 2^{a}
CS21-243	91 ± 2^{ab}	94 ± 3^{a}
BC113-05	89 ± 3^{abc}	93 ± 4^{abc}
ISRA-S-754-81	89 ± 4^{abc}	92 ± 4^{abc}
ISRA-S-754-79	$88 \pm 1^{a\text{-}d}$	$91 \pm 1^{a\text{-}d}$
TEMOIN 1	$86 \pm 3^{a\text{-}e}$	$90 \pm 2^{a\text{-}d}$
014-SB-EPDU-1004	$85 \pm 1^{a\text{-}e}$	$89 \pm 2^{a\text{-}e}$
ICSV 206091	$83 \pm 3^{a\text{-}e}$	$87 \pm 3^{a\text{-}g}$
SASSILON	$83 \pm 2^{a\text{-}e}$	$88 \pm 2^{a\text{-}f}$
ICSV 206079	$81 \pm 3^{b\text{-}f}$	$83 \pm 2^{b\text{-}g}$
06-SB-F5DT-15	$79 \pm 4^{c\text{-}g}$	$85 \pm 3^{b\text{-}g}$
ICSB 176008	$79 \pm 1^{c\text{-}g}$	$84 \pm 1^{b\text{-}g}$
ITRASV221070	$79 \pm 2^{c\text{-}g}$	$86 \pm 2^{a\text{-}g}$
SOUBATIMI	$78 \pm {}^{1c\text{-}g}$	$83 \pm 2^{c\text{-}g}$
ITRASV221107	$77 \pm 4^{d\text{-}g}$	$83 \pm 4^{b\text{-}g}$
ISRA-S-756-27	76 ± 1^{efg}	$82 \pm 1^{c\text{-}g}$
ISRA-S-756-34	76 ± 3^{efg}	$82 \pm 1^{c\text{-}g}$

Continued

SARIASO 14	75 ± 1^efg	79 ± 2^d-g
ICSV 1460016	71 ± 2^fg	77 ± 3^fg
ICSB 176003	70 ± 3^fg	77 ± 3^efg
ITRASV2211084	70 ± 1^fg	80 ± 2^d-g
SARIASO 16	68 ± 1^g	76 ± 7^g
Moyenne	81	86
Probability	<0.001	<0.001
Signification	THS	THS

Note: THS: highly significant. Means assigned the same letters are not significantly different at the 5% level (Bonferoni test).

3.2. Disease Parameters

The main biotic and physiological constraints observed during the trial were foliar anthracnose, lodging tendency, zoned leaf spot disease and grain mold severity.

Table 3 observation allows to assess the severity of the different diseases (anthracnose, zoned spot, and seed mold severity) on the varieties studied. Analysis of variance revealed highly significant differences between varieties for anthracnose ($P < 0.0001$). The varieties ISRA-S-754-81, BC113-05, and BC110-19 were not infested by anthracnose. Among the others, the varieties Soubatimi, ITRASV221070, CS21-243, 06-SB-F5DT-15, and 014-SB-EPDU-1004 proved to be the most resistant, while ICSB 176003, ICSV 166001, ICSB 176008, and ICSV 206091 were the least resistant. The remaining varieties exhibited intermediate resistance.

For the zoned spot parameter, the results showed that the most resistant varieties were ISRA-S-754-81, SASSILON, ISRA-S-756-34, and BC110-19, while the varieties ICSV 206091, Control 1, ICSV 206079, ISRA-S-754-79, and ISRA-S-756-27 were the least resistant.

Regarding the severity of seed mold, the Control 1 variety was not infested. The most resistant varieties are ISRA-S-754-79, BC113-05, MDK, ICSV 206079, and BC110-19, while the least resistant are ISRA-S-756-27, ITRASV221107, Soubatimi, and ICSV 1460016. The remaining varieties represent an intermediate group in terms of resistance.

Table 3. Analysis of parameters for the different diseases.

Varieties	Anthracnose	Severity	zoned spot	Severity	seed mold	Severity
ICSB 176003	4.00^a	S	3.33^ab	MS	2.00 ± ab	R
ICSV 166001	4.00^a	S	4.33^a	S	0.00^b	A
ICSB 176008	3.66^a	S	3.33^ab	MS	1.66^abc	R
ICSV 206091	3.66^a	S	3.00^abc	MS	1.00^ab	TR

Continued

MDK	3.33^{a}	MS	1.33^{bcd}	TR	0.66^{ab}	TR
TEMOIN 1	3.33^{a}	MS	3.00^{abc}	MS	0.00^{b}	A
SARIASO 14	3.00^{a}	MS	1.66^{bcd}	R	2.00^{ab}	R
ISRA-S-756-34	1.00^{bc}	TR	1.00^{cd}	TR	1.00^{ab}	TR
ITRASV2211084	1.00^{bc}	TR	1.33^{bcd}	TR	3.00^{a}	MS
SARIASO 16	1.00^{bc}	TR	2.33^{a-d}	R	3.00^{a}	MS
ICSV 1460016	0.66^{bc}	TR	1.66^{bcd}	R	2.00^{ab}	R
ICSV 206079	0.66^{bc}	TR	2.33^{a-d}	R	0.66^{ab}	TR
ISRA-S-754-79	0.66^{bc}	TR	2.00^{a-d}	R	0.33^{b}	TR
ISRA-S-756-27	0.66^{bc}	TR	2.00^{a-d}	R	3.00^{a}	MS
ITRASV221107	0.66^{bc}	TR	1.66^{bcd}	R	2.66a	MS
SASSILON	0.66^{bc}	TR	1.00^{cd}	TR	1.33^{ab}	TR
014-SB-EPDU-1004	0.33^{c}	TR	1.66^{bcd}	R	0.33^{b}	TR
06-SB-F5DT-15	0.33^{c}	TR	1.33^{bcd}	TR	1.00^{ab}	TR
CS21-243	0.33^{c}	TR	1.00^{cd}	TR	0.33^{ab}	TR
ITRASV221070	0.33^{c}	TR	0.33^{d}	TR	2.00^{ab}	R
SOUBATIMI	0.33^{c}	A	1.33^{bcd}	TR	2.33^{ab}	R
BC110-1CE9	0.00^{c}	A	1.00^{cd}	TR	0.66^{ab}	TR
BC113-05	0.00^{c}	A	1.33^{bcd}	TR	0.33^{ab}	TR
ISRA-S-754-81	0.00^{c}	A	0.66^{cd}	TR	1.00^{ab}	TR
Moyenne	1.44	TR	1.88	TR	1.35	TR
Probability	<0.001		<0.001		<0.001	
Signification	THS	THS	THS	THS	THS	

Note: A: absent, **TR**: very resistant, **R**: resistant, **MS**: moderately sensitive, **S**: sensitive, **THS**: highly significant. Means with the same letter are not significantly different at the 5% level (Bonferoni test).

3.3. Morphological Parameters

Analysis of variance revealed highly significant differences for all morphological parameters (Number of Green Leaves, Plant Height).

3.3.1. Number of Green Leaves

The results of the analysis variance of green leave showed that the average number of green leaves varies between 3 and 7.5 leaves. Figure 1 shows the performance of the different varieties in relation to the average number of green leaves. Observation showed that the varieties ICSB 176008 (7.50), SOUBATIMI (6.91), ICSV1460016 (6.83), SARIASO 14 (6.83), ITRASV2211084 (6) which presented the highest numbers of green leaves, while the lowest numbers were found with the varieties ISRA-S-756-34 (3), ISRA-S-754-81 (3.91), ITRASV221070 (4), BC113-05 (4), ITRASV221107 (4.33).

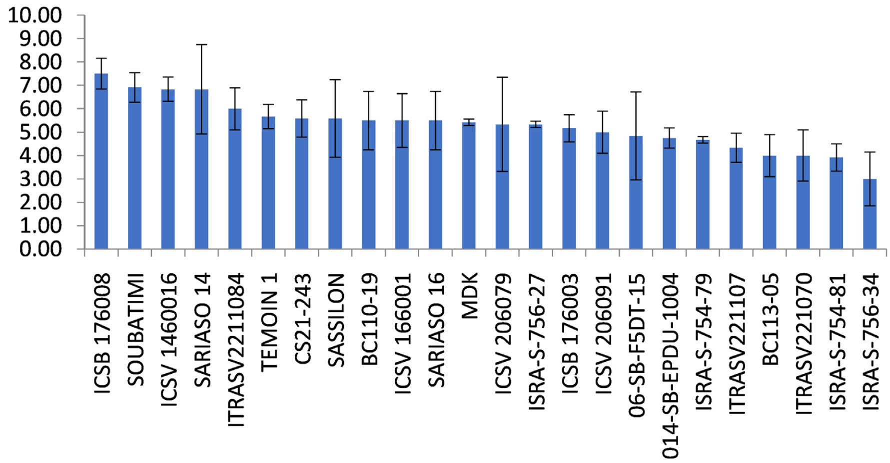

Figure 1. Average number of green leaves of the 24 sorghum varieties, the bars represent the standard deviations.

3.3.2. Plant Height

The analysis of variance of the variable plant height (**Figure 2**) revealed a highly significant difference. For this trait, the varieties TEMOIN 1 (337 cm), MDK (263.08 cm), BC110-19 (222.25 cm), ICSB 176008 (211.17 cm), and ICSV 206079 (181 cm) exhibited the tallest heights, while the varieties BC113-05 (128 cm), ISRA-S-756-27 (128.50 cm), ISRA-S-754-81 (130.08 cm), CS21-243 (130.08 cm), and ITRASV221107 (134.33 cm) exhibited the shortest average plant heights.

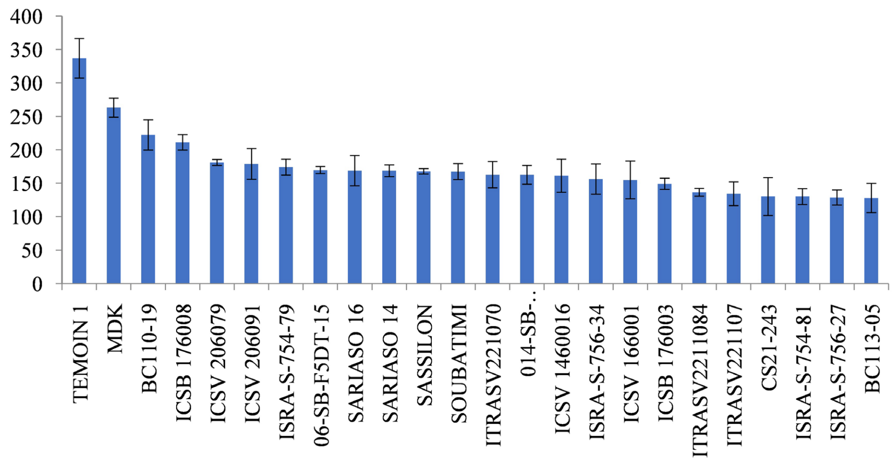

Figure 2. Average plant height of the 24 sorghum varieties; the bars represent standard deviations.

3.4. Yield Parameters and Their Components

Analysis of variance revealed highly significant differences of the different parameters: Number of harvested hills, Number of harvested panicles, Weight of seeds per plot, Weight of 1000 seeds, Weight of dry biomass, Grain yield per hectare.

3.4.1. Number of Harvested Plantings

Analysis of variance of this variable revealed that the number of harvested plantings varied from 13.66 to 22. Specifically, the number of harvested plantings was 100% in the plots of the following varieties: CS21-243 (22), ICSB 176003 (22), ISRA-S-756-27 (22), ITRASV2211084 (22), MDK (22), SASSILON (22), and SOUBATIMI (22), each with 22 plantings. The lowest average number of harvested plantings was found in the plots of the varieties 014-SB-EPDU-1004 and ICSV 206079 (**Figure 3**).

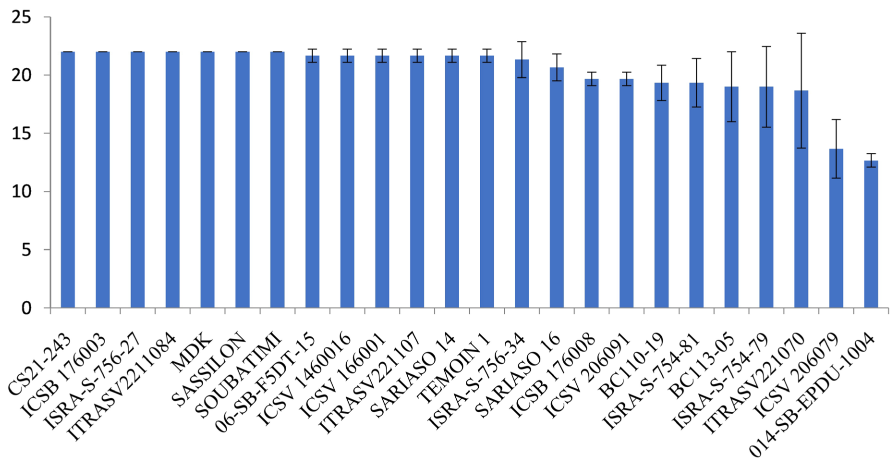

Figure 3. Average number of harvested planting hills of the 24 sorghum varieties; the bars represent standard deviations.

3.4.2. Number of Harvested Panicles

According to the **Figure 4**, the analysis of variance of the number of harvested panicles showed that the number ranged from 22.66 to 64.66 panicles. It was observed that the varieties ICSB 176003 (64.66), SOUBATIMI (63.66), ISRA-S-756-27 (61), SB-F5DT-15 (59.66), and ICSV 1460016 (59.66) had the highest numbers of harvested panicles, while the varieties ICSV 206079 (22.66), 014-SB-EPDU-1004 (26.66), ISRA-S-754-81 (37.33), SARIASO 14 (44), and ICSV 206091 (44) had the lowest numbers.

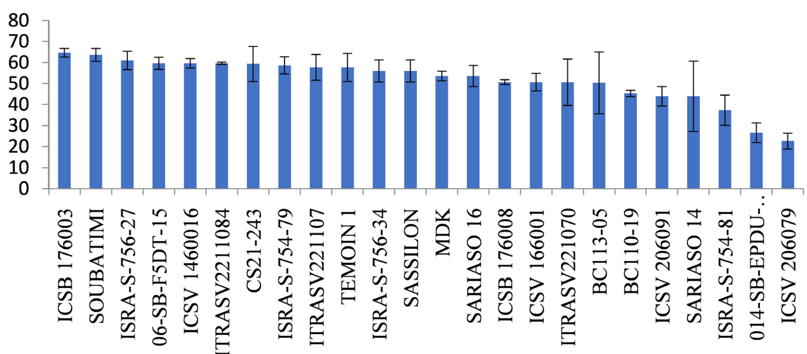

Figure 4. Average number of panicles harvested from the 24 sorghum varieties; the bars represent standard deviations.

3.4.3. Seed Weight Per Plot

For the seed weight variable, the analysis showed that values ranged from 668.67

g to 2119.3 g per plot. The varieties with the highest weights were MDK (2119.3 g), SASSILON (1432.7 g), ICSB 176003 (1345.3 g), 014-SB-EPDU-1004 (1316.7 g), and Soubatimi (1215.3 g). Inversely, the lowest weights were observed in the varieties ICSV 206079 (668.67 g), ITRASV221070 (702 g), ISRA-S-754-81 (712.67 g), BC113-05 (731.33 g), and BC110-19 (751.33 g) (**Figure 5**).

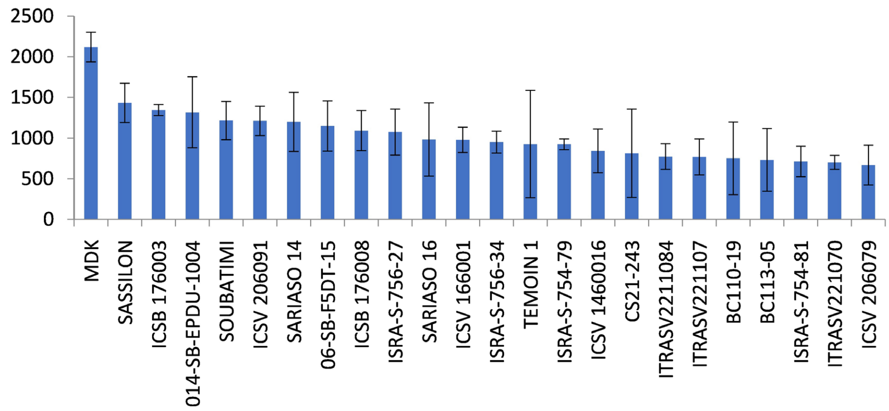

Figure 5. Average weight of seed mass per plot of the 24 sorghum varieties; the bars represent the standard deviations.

3.4.4. 1000-Seed Weight

The performance of the varieties in terms of 1000-seed weight, the analysis of variance showed that this weight ranged from 14 g to 31.33 g. The varieties with the highest weights were MDK (31.33 g), BC110-19 (22.66 g), Control 1 (22.66 g), ISRA-S-754-81 (20.66 g), and ITRASV2211084 (20.66 g). Conversely, the lowest weights were observed in ITRASV221070 (14 g), BC113-05 (14 g), 06-SB-F5DT-15 (14.66 g), ICSV 206091 (16 g), and ICSV 1460016 (16 g) (**Figure 6**).

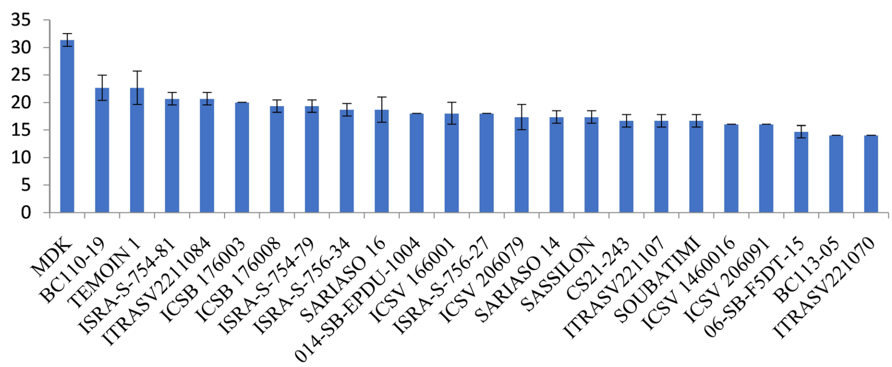

Figure 6. Average weight of 1000 seeds of the 24 sorghum varieties; the bars represent the standard deviations.

3.4.5. Dry Biomass Weight

The analysis for the variable dry biomass weight per plot as shown in **Figure 7**, showed that the values varied from 2403.3 g to 7263.3 g. The varieties with the highest weights were Control 1 (7263.3 g), MDK (6368.3 g), BC110-19 (5926.3 g), ICSV 206091 (5786.7 g) and Soubatimi (5545 g), with the Control 1 variety being the most efficient. Conversely, the lowest weights were observed in BC113-05 (2403.3 g), ISRA-S-754-81 (2650 g), ICSB 176003 (2835 g), ISRA-S-756-34 (2958.3 g) and 014-SB-EPDU-1004 (3096.7 g).

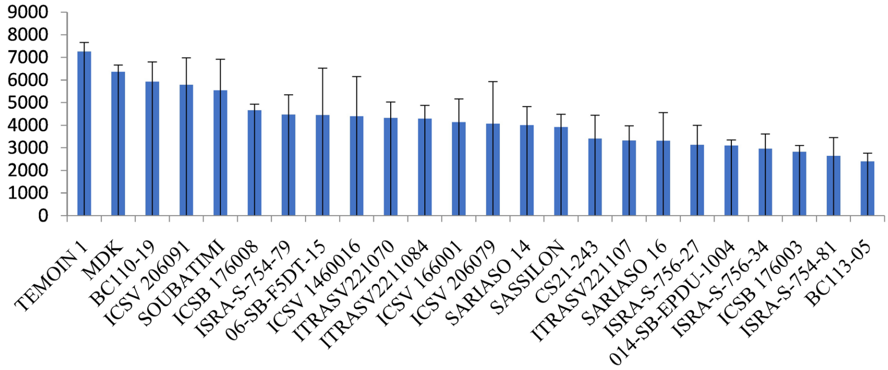

Figure 7. Average weight of dry biomass of the 24 sorghum varieties; the bars represent standard deviations.

3.4.6. Grain Yield Per Hectare

For the grain yield per hectare, the analysis showed that the values varied from 2089.6 kg to 6622.9 kg/ha. The varieties with the highest yields were MDK (6622.9 kg/ha), SASSILON (4477.1 kg/ha), ICSB 176003 (4204.2 kg/ha), 014-SB-EPDU-1004 (4114.6 kg/ha) and Soubatimi (3797.9 kg/ha). On the other hand, the lowest yields were observed in ICSV 206079 (2089.6 kg/ha), ITRASV221070 (2193.8 kg/ha), ISRA-S-754-81 (2227.1 kg/ha), BC113-05 (2285.4 kg/ha) and BC110-19 (2347.9 kg/ha) (Figure 8).

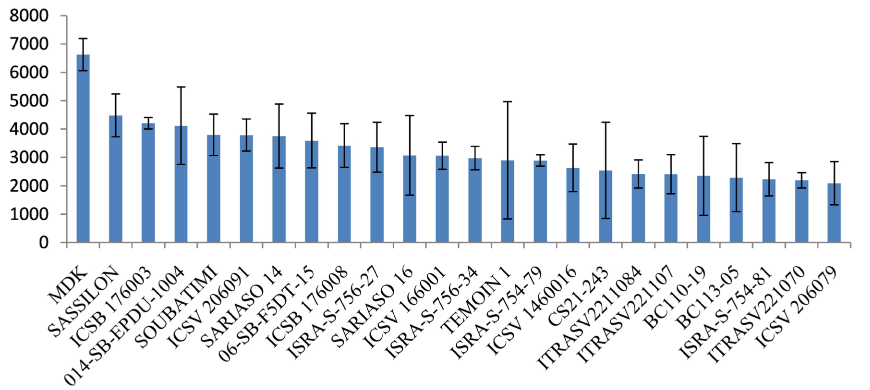

Figure 8. Average grain yield per hectare of the 24 sorghum varieties; the bars represent the standard deviations.

3.5. Correlation Analysis between Different Parameters

According to Table 4, correlation analysis revealed both positive and negative relationships between the parameters. Seed mold severity was highly negatively correlated with flowering date (r = −0.7316) and the date of 50% flowering (r = −0.9532). Plant height was highly positively correlated with anthracnose (r = 0.4302) and highly positively correlated with the number of green leaves (r =

0.2429). Flowering date was highly positively correlated with zoned leaf spot (r = 0.2672). Plant height was negatively correlated with seed mold severity (r = −0.3204) and highly positively correlated with dry biomass (r = 0.6962) and 1000-seed weight (r = 0.5732). The number of harvested hills is positively significant with the severity of the mold (r = 0.2439).

The number of panicles was highly positive with mold severity (r = 0.3690) and highly negative with flowering date (r = −0.3494) and the date of 50% flowering (r = −0.3138). Dry biomass weight was highly positive with anthracnose (r = 0.3247) and the number of green leaves (r = 0.3330).

The 1000-seed weight was highly positive with flowering date (r = 0.2734) and the date of 50% flowering (r = 0.2823). Yield is positively highly significant with anthracnose (r = 0.3572), 1000 seed weight (r = 0.4371) and seed weight per plot (r = 1), and positively significant with dry biomass (r = 0.3001) and number of harvested hills (r = 0.2913).

Table 4. Correlations between certain agronomic parameters in the 24 varieties.

	ANTRAX	TZ	GM	DFL	D50	FV	
ANTRAX	1						
TZ	**0.6395**	1					
GM	−0.1117	−0.1317	1				
DFL	−0.0114	−0.0270	−0.7316	1			
D50	−0.0435	−0.0666	**−0.6960**	**0.9532**	1		
FV	0.2067	**0.2231**	0.2602	−0.2058	**−0.2466**	1	
HP	**0.4302**	**0.2672**	**−0.3204**	**0.2237**	0.1811	**0.2429**	
NPR	**0.2326**	0.0003	**0.2439**	−0.1998	−0.1689	0.0828	
NpaP	0.0768	−0.0048	**0.3690**	**−0.3494**	**−0.3138**	0.0941	
PBSP	**0.3247**	0.1900	−0.0658	0.1267	0.1097	**0.3330**	
PgrP	**0.3572**	0.1633	0.0600	−0.0607	−0.0940	0.1949	
P1000	**0.3689**	0.0947	−0.1918	**0.2734**	**0.2823**	0.0637	
rdt	**0.3572**	0.1633	0.0600	−0.0607	−0.0940	0.1949	
	HP	NPR	NpaP	BS	PgrP	P1000	RDT
HP	1						
NPR	0.0740	1.0000					
Npa	0.0359	**0.8343**	1				
BS	**0.6962**	0.2040	0.1714	1			
Pgr	**0.2881**	**0.2363**	**0.2913**	**0.3001**	1		
P1000	**0.5732**	0.1532	0.0164	**0.3983**	**0.4371**	1	
RDT	**0.2881**	**0.2363**	**0.2913**	**0.3001**	1.0000	**0.4371**	1

Note: Anthrax: anthracnose, TZ: zoned spot, GM: severity of seed mold, DFL: flowering date, D50F: 50 flowering dates, FV: green leaves, HP: plant height, NPR: number of harvested hills, NpaR: number of panicles, PBS: dry biomass weight, PGP: seed weight per plot, P1000: weight of 1000 thousand seeds, RDT: seed yield.

4. Discussion

The significant variability observed among sorghum varieties for phenological, morphological, phytosanitary, and yield-related traits reflect strong genetic diversity among the tested germplasm. Such diversity is essential for identifying varieties adapted to specific agro-ecological conditions, particularly in rainfed systems characterized by climatic uncertainty such as the Sudanian zone of southwestern Niger.

Late-maturing varieties generally exhibited greater plant height and biomass production, confirming that longer vegetative cycles allow extended photosynthetic activity and greater assimilate accumulation. This trend is consistent with previous studies reporting a positive association between cycle length, plant height, and biomass production in sorghum grown under favorable rainfall conditions [7] [8]. In Bengou, where rainfall during the experimental period was within the normal range (820 mm - 830 mm), late-maturing varieties were able to fully exploit available soil moisture, resulting in enhanced vegetative growth.

Plant height plays an important role in lodging susceptibility, productivity and intercropping potential [9]. A short stem height, less than 2 m, is often preferred for the intensification of rainfed crops [10]. The observed variation in plant height can be explained by the genetics of the varieties and their adaptability to the environment. The number of mature green leaves ranged from 3 to 7.5, with variety ICSB 176008 exhibiting the maximum and ISRA-S-756-34 the minimum. Green leaf area is essential for photosynthesis, light capture, and CO_2 fixation, directly contributing to biomass production [11]. A positive correlation between the number of green leaves and dry biomass confirms the importance of foliage in dry matter accumulation [12].

The strong performance of the MDK variety can be attributed to its local adaptation to the Sudanian agro-ecological conditions of Gaya. Its tall stature, high dry biomass, and superior 1000-seed weight indicate efficient assimilate partitioning toward both vegetative and reproductive organs. Despite producing fewer panicles than some varieties, MDK achieved the highest grain yield, demonstrating that grain yield in sorghum is more strongly influenced by grain filling efficiency and seed weight than by panicle number alone. This finding is supported by the strong positive correlations observed between grain yield, seed weight per plot, and 1000-seed weight.

Disease pressure varied significantly among varieties, highlighting differences in genetic resistance. The high resistance observed in most varieties to anthracnose and zoned leaf spot likely contributed to maintaining green leaf area during grain filling, thereby supporting sustained photosynthesis and yield stability [13]. Disease tolerance is particularly important in smallholder systems where chemical control options are limited. The negative correlation between seed mold severity and flowering time suggests that late-maturing and taller varieties may escape late-season humidity conditions that favor mold development, as previously reported [14].

A negative correlation between the date of 50% flowering and the number of harvested panicles suggests that delayed flowering can reduce the number of productive panicles, particularly in Sahelian regions where rainfall can cease early [6]. Furthermore, the positive correlation between the number of green leaves and cycle length shows that, in C4 plants such as sorghum, the number of leaves increases with cycle length [15], confirming previous observations.

Although the grain yields obtained under experimental conditions were substantially higher than the national average, this difference can be explained by optimal crop management practices, including timely sowing, appropriate plant density, and effective weed control. Nevertheless, the strong performance of locally developed varieties such as MDK suggests that significant yield gains are achievable under farmer conditions if basic agronomic practices are improved. This confirms that productivity gains in Niger can be achieved not only through exotic germplasm but also through the optimization and dissemination of well-adapted local varieties.

MDK's high grain yield is mainly attributed to its local adaptation, tall stature and high biomass, superior grain filling (high thousand-seed weight), and good tolerance to major diseases, combined with optimal experimental management conditions. Although yields exceeded the national average, MDK's local origin supports its potential for scaling under improved agronomic practices in Niger.

5. Conclusion

This study demonstrated significant agronomic variability among sorghum varieties evaluated at INRAN Bengou research station. Several varieties showed superior grain yield, early maturity, and strong resistance to anthracnose and zoned leaf spot. The locally adapted variety MDK exhibited the highest grain yield, associated with high biomass production and superior grain weight, highlighting its strong potential for scaling under improved agronomic management. These results confirm that yield improvement in Niger can be achieved through the promotion of locally adapted varieties combined with appropriate crop management practices.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] FAOSTAT (2021) Food and Agricultural Organization of the United Nations (FAO) Statistics, Statistics Division. http://www.fao.org/faostat/fr/#data/QC/visualize/

[2] FAOSTAT (2015) FAOSTAT Statistical Database. Organisation des Nations Unies pour l'Alimentation et l'Agriculture (FAO).

[3] FAO (2022) FAOSTAT statistical database. Organisation des Nations Unies pour l'Alimentation et l'Agriculture (FAO).

[4] Agrama, H.A. and Tuinstra, M.R. (2003) La diversité phylogénétique et les relations

entre le sorgho adhésions à l'aide SSR et RAPD. *African Journal of Biotechnology*, **2**, 334-340.

[5] Touré, A., Diallo, A. and Touré, A.O. (2005) Mise au point de variétés de sorgho dans une perspective d'utilisation industrielle au Mali. Rapport de recherche, campagne 2004-2005, Institut de recherche agricole du Mali (IER), Bamako.

[6] Togo, A. (2019) Effets de la fertilisation et de la date de semis sur des variétés de sorgho à double usage. Mémoire de fin de cycle Université IPR/IFRA de Katibougou, 50 p.

[7] Cochemé, J. and Franquin, P. (1967) A Study of the Agroc1imatology of Semi-Arid Area South of the Sahara in West Africa. FAO/UNESCO, 325 p.

[8] Zongo, J.D. (1991) Étude de la variabilité morphologique et agronomique du sorgho (*Sorghum bicolor* L. Moench) au Burkina Faso. Thèse de Doctorat, Université de Ouagadougou.

[9] Bretaudeau, A., Bakary, T., Ousmane, N., Adama, B. and Sako, D. (2001) Variabilité génétique des sorghos de décrue au Mali. In: Comas, J. and MacPherson, H.G., Eds., *La culture du sorgho de décrue en Afrique de l' Ouest et du centre*, Publié par l'Agence Espagnole de coopération internationale avec la collaboration de la FAO, 123-141.

[10] Luce, C. (1988) L'amélioration variétale du sorgho au Sénégal. Acquis (1950-1986) et perspectives de recherches. Univalisra, études et documents 1: 2. 22 p.

[11] Khan, T.N., Ramzan, A., Jillani, G. and Mehmood, T. (2013) Morphological Performance of Peas (*Pisumsativum* L.) Genotypes under Rainfed Conditions of Potowar Region. *Journals of Agricultural Research*, **51**, 1-8.

[12] Ouattara, K. (2017) Leaf Area and Photosynthetic Efficiency in Cereal Crops. *Journal of Applied Plant Science*, **12**, 45-55.

[13] Kondombo, C.P. (2001) Evaluation agronomiques et fourragères de 194 lignées recombinantes de sorgho. Mémoire d'ingénieur du développement rural, Université Polytechnique de BOBO-DIOULASSO, 123 p.

[14] Ouedraogo, M. (2014) Etude de la diversité agro-morphologique du sorgho et identification de cultivars tolérants au stress hydrique postfloral. Mémoire, Ingénieur en Agriculture, Centre Agricole Polyvalent de Matourkou, 88 p. http://www.memoireonline.com

[15] Chantereau, J. (1993) Étude de l'hétérosis chez le sorgho (*Sorghumbicolor* L. Moench) par l'exploitation d'écotypes et l'analyse de leurs divergences. Thèse de docteur en Sciences, Université Paris XI Orsay, 206 p.