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# Screening Some Sorghum (*Sorghum Bicolor L. Moench*) Genotypes for Yield and Resistance Against Stem Borer (*Sesamia Calamistis*) in Nigeria

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***Abstract***

*Sorghum is a staple crop with global significance, scientifically it's known as Sorghum Bicolor, stands as one of the most important cereal crops globally, particularly in regions with arid and semi-arid climates. Sorghum remains a cornerstone of agricultural economies worldwide with its widespread cultivation and diverse applications; however, its production is often hindered by various biotic stresses, with stem borer (Sesamia calamistis) infestation being a significant concern. The stem borer (S. calamistis) threatens sorghum production (Sorghum bicolor (L.) Moench) in Nigeria. This is a serious issue since sorghum is vital for farmers' livelihoods and food security. Urgent action is needed to combat this pest and protect agriculture. This study aimed to evaluate the resistance levels of elite sorghum genotypes to stem borer infestation in a confined environment (screen house). A total of 40 elite sorghum genotypes from Institute of Agricultural Research Zaria were subjected to controlled infestation with S. calamistis under screen house conditions in National Biotechnology Research and Development Agency, Abuja, Nigeria for tolerance/resistance to S. calamistis during rainy season of 2023. Test plants were artificially infested with five stem borer neonates, and data were recorded, and Observations were made on various parameters including, leaf damage, dead heart, exit hole, tunnel length, agronomic and yield components. Results revealed varying degrees of resistance among the tested genotypes, based on selection index generated, genotypes SAMSORG 48, SAMSORG 49, SAMSORG 50, SAMSORG 51, SOUMBA, ICSB 464, and ICSL 71268 were resistant indicating the potential for breeding programs to develop stem borer-resistant and high yield sorghum varieties tailored to the Nigerian agro-ecosystem.*

**Keywords:** Stem borer, *Sesamia Calamistis*, Sorghum bicolor, resistance, genotypes, Nigeria

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## INTRODUCTION

Sorghum is a staple crop with global significance, scientifically it is known as *Sorghum Bicolor*, and stands as one of the most important cereal crops globally, particularly in regions with arid and semi-arid climates [1]. In Nigeria, Sorghum holds a significant position within the agricultural landscape, contributing substantially to food security and economic stability. Nigeria stands as one of the leading producers of sorghum in Africa, with a production rate that reflects its vital role in the country's agricultural sector. Across Africa, sorghum production serves as a cornerstone of food production and livelihoods for millions, particularly in regions where other crops struggle to thrive. Moreover, on a global scale, sorghum holds its ground as a valuable crop, with production spanning various continents and catering to diverse agricultural systems and consumer demands [1].

The economic importance of sorghum transcends local, national, and international boundaries, impacting various sectors ranging from agriculture to industry and beyond. In Nigeria, sorghum plays a pivotal role in the economy by providing a source of income for farmers, supporting rural livelihoods, and contributing to food security Its versatility extends to multiple uses, including human consumption, animal feed, and industrial applications, such as biofuel production and brewing. As a gluten-free grain, sorghum also holds promise in catering to dietary needs and preferences, both domestically and globally. Its resilience to drought and heat stress further enhances its economic significance, especially in the face of climate change challenges [2].

Sorghum remains a cornerstone of agricultural economies worldwide with its widespread cultivation and diverse applications, however, its production is often hindered by various biotic stresses, with stemborer (*Sesamia calamistis)* infestation being a significant concern. The stem borer (*S. calamistis*) threatens sorghum production (Sorghum bicolor (L.) Moench) in Nigeria. This is a serious issue since sorghum is vital for farmers' livelihoods and food security. Urgent action is needed to combat this pest and protect agriculture. Extensive damage caused by stemborers to sorghum plants leads to high yield losses and economic setbacks for farmers. In Nigeria, where sorghum cultivation plays a crucial role in food security and rural livelihoods, addressing stem borer infestation is imperative. Breeding for resistance to this pest is a sustainable approach to mitigate its impact on sorghum production. The effectiveness of pesticides is inherently limited, particularly when larvae are situated within the stalks of the plant (Kfir et al., 2002). Consequently, host plant resistance is considered the most viable strategy for pest management. When such resistance is available, it represents one of the most effective methods for controlling insect pests. This approach is environmentally sustainable, aligns well with other pest management strategies, incurs no additional cultivation costs, and has demonstrated success in managing various insect pests in sorghum [3]. Furthermore, enhancing resistance to *S. calamistis* necessitates the identification of new resistance sources to broaden the resistance framework against this pest [4, 5].

Therefore, the objective of this study is to evaluate the resistance levels of some elite sorghum genotypes to stem borer infestation in a confined environment (screen house), to identify new sources with diverse mechanisms of resistance to *S. calamistis.*

## MATERIALS AND METHODS

### Experimental Site

Experiments to evaluate sorghum genotypes against *Sesamia calamistis* damage was conducted at Screen House of Agriculture Biotechnology Department, National Biotechnology Research and Development Agency Lugbe, Abuja, Nigeria. Lugbe in Abuja is situated at approximately 300 m above sea level, Lugbe Abuja offers a moderate elevation conducive to various research endeavors. The average minimum temperature in Lugbe ranges from 18–22ºC to 30–40ºC for maximum temperature, these temperatures create a subtropical climate ideal for studying various environmental and biological phenomena. Lugbe Abuja has a tropical climate with wet and dry seasons, noted for its clear distinction between the rainy and dry periods. The rainy season usually lasts from April to October, with the highest rainfall occurring between June and September.

The average annual rainfall in Lugbe is approximately 1,300–1,500 millimeters, providing ample opportunity for research on precipitation patterns, hydrology and ecosystem dynamics [6].

 

### Experimental Material and Design

Forty elite sorghum genotypes were chosen for this study based on their established agronomic performance and genetic variation; these varieties are favored by farmers, and their grains and stover are used for both food and animal feed. The genotypes were grown in pots arranged in a randomized complete block design with three replications under screened conditions to avoid interference from external pests. The rows measured 2 meters in length, with a spacing of 0.75 meters between them, and the distance between the plants was 0.25 meters. All recommended cultivation practices were adhered to produce a healthy crop. Two weeks after planting, the crop was treated with cypermethrin (a synthetic pyrethroid) to reduce shoot fly infestation, as this pest complicates the assessment of resistance to stem borers. The neonate stem borers used for this research were sourced from the Institute for Agricultural Research (IAR). At 21 days post-planting, five plants in each row were intentionally infested in the whorl with five larvae per plant, using a camel hairbrush. The infestation was conducted early in the morning to promote the survival of the larvae.

## DATA COLLECTION

The data collection process involved systematic recording of various parameters on a per-plant basis at two distinct time points: two weeks and four weeks following artificial infestation with pests. To evaluate leaf damage, we assessed the percentage of plants exhibiting pinhole damage, calculated by dividing the number of affected plants by the total number of plants sampled and then multiplying by 100 to represent it as a percentage. To determine the incidence of dead-heart damage in the plants, we recorded the number of plants showing symptoms of this condition and expressed it as a percentage of the total samples collected. At the time of harvest, we meticulously counted the number of exit holes made by stem borers on the stems of each sampled plant, providing insight into the extent of damage inflicted. In addition to these observations, we carefully inspected the main stems of plants infested with *S. calamistis* larvae. Each stem was split open longitudinally from the base to the apex, allowing for an accurate measurement of the cumulative tunnel length, which was recorded in centimeters. This measure helps to gauge the level of infestation and damage caused by the larvae. When the plants reached physiological maturity, we measured their height from the base to the tip of the panicle to assess growth performance. Furthermore, we recorded the number of days taken to reach 50% flowering, defined as the number of days elapsed from the planting date until half of the plants within a specific plot had reached anthesis. This timing is critical for understanding the flowering dynamics of different genotypes. To maintain consistency, all genotypes were harvested on the same day to ensure comparability of data across the study.

### Statistical Analysis

Percentages were transformed using angular transformation, while counts underwent log transformation prior to conducting the variance analysis. The mean trait values for every replicate were utilized to perform the analysis of variance through the Statistical Tool for Agricultural Research. Treatment means were compared via a protected Fisher’s least significant difference (LSD) test at a significance level of $P = 0.05$. The borer damage selection index was determined by aggregating the ratios of leaf damage, dead hearts, and exit holes for each genotype compared to the overall mean of each parameter, and then dividing by 4 (the number of damage parameters considered). Genotypes were classified into four categories: resistant, moderately resistant, moderately susceptible, and susceptible [7].

## RESULTS AND DISCUSSION

### Results

The analysis of variance revealed highly significant differences ($P < 0.01$) in both resistant traits (including leaf damage, dead heart formation, stem tunneling, and exit holes) and Agronomic Traits (such as panicle length, total grain yield, and one thousand grain weight) among the tested genotypes (see Tables 1 and 2) [8].

Genotypes observed to show low Dead Heart were SSV2004 (12.4%), ICSL 71268 (16.20%), ICSL 71061 (16.40%), and Samsorg 38 (17.4%) increasing order while the following genotypes, Samsorg 3 (11.1%), ICSL 71018 (13.3%), SSV2004 (35.20%), and Samsorg 17 (17.43%) suffered the least leaf damage also in increasing order. Stem tunnel length and exit hole range from 0.00 to 5.5, respectively (Table 3).

**Table 1.** Mean squares for agronomic traits.

| Source of Variation | Degree of Freedom | Germination Percentage | Seedling Vigor | Panicle Length | Plant Height | 1000 GW | Day to 50% Flowering | Grain Yield |
|---|---|---|---|---|---|---|---|---|
| Pedigree | 39 | 4356.8376** | 8.2596** | 16.4164* | 547.4639** | 3.6569** | 72.1162** | 9142.3077** |
| Error | 80 | 375.000 | 1.5500 | 13.3488 | 916.4153 | 4.0835 | 68.047 | 10208.7500 |
| Total | 119 | | | | | | | |

*Note: * Significant at 5% level, ** Significant at 1% level.*

Genotype SRN39-2 (76.2%) and ICSB 464 (52.6%) in descending order recorded the highest dead heart damage, respectively, while KL-1 (83.4%) and NRL-1 (73.6%) recorded highest leaf damage. The genotype twin seed (5.5 cm) recorded the highest for tunneling length and KSV15 (5.2 cm) was observed to have the highest for exit hole among the 40 tested genotypes (Table 3).

Plant height ranged from 85.0 cm to 168.9 cm with Karura Maiduguri recorded the highest and KAT487 recorded the lowest. Panicle length ranged from 13.2 cm to 26.8 cm with ICSL 71018 as the longest and SSV20041 as the shortest (Table 3).

Genotypes with highest and lowest grain weight were ICSB 646 and SSV20041, respectively (Table 3).

Highest grain yield (>0.05 kg) ICSB 464 while lowest grain yield was recorded on (<0.001 kg). Based on the selection index, 47.5% of genotypes evaluated were categorized as moderately resistant, 20% as resistant, 22.5% moderately susceptible and 7.5% as susceptible (Table 3) [9].

**Table 2.** Mean Squares for Resistant Traits.

| Source of Variation | Degree of Freedom | Leaf Damage (2 wks) | Leaf Damage (4 wks) | Dead Heart | Dead Heart (2 wks) | Dead Heart (4 kws) | Exit Hole | Tunnel Length |
|---|---|---|---|---|---|---|---|---|
| Pedigree | 39 | 1122.7350** | 1790.6838** | 19.8288** | 11.22.7350** | 1989.6581** | 0.4752* | 0.705* |
| Error | 80 | 376.6667 | 600.0000 | 18.6500 | 376.6667 | 720.000 | 0.4583 | 0.8671 |
| Total | 119 | | | | | | | |

*Note: * Significant at 5% level, ** Significant at 1% level.*

**Table 3.** Reaction of some sorghum varieties to stem borer during the 2023 planting season in the screening environment.

| Entry | Dead Heart (%) | Leaf Damage (%) | Stem Tunnel Length (cm) | No. of Exit Hole | Selection Index | Category | Plant Height (cm) | Panicle Length (cm) | Grain Weight (Kg) | Grain Yield (Kg/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| CSR01 | 29.10 | 51.90 | 1.50 | 0.50 | 0.60 | MR | 136.70 | 18.20 | 0.002 | 0.025 |
| DALAWANDA | 22.50 | 59.10 | 2.80 | 1.30 | 0.70 | MR | 151.70 | 14.00 | 0.001 | 0.001 |
| FARA2BAUCHI | 46.40 | 45.00 | 1.70 | 0.80 | 0.70 | MR | 114.70 | 14.30 | 0.0029 | 0.018 |
| ICSL 71018 | 27.40 | 13.30 | 0.00 | 0.00 | 0.70 | MR | 143.00 | 26.80 | 0.0025 | 0.025 |
| ICSL 71137 | 51.60 | 58.30 | 1.10 | 0.30 | 0.70 | MR | 117.90 | 20.10 | 0.0031 | 0.036 |
| KAT 487 | 35.80 | 57.70 | 1.50 | 1.00 | 0.70 | MR | 168.90 | 17.90 | 0.0016 | 0.019 |

 

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| KL-1 | 16.40 | 83.40 | 2.40 | 1.60 | 0.80 | MR | 164.10 | 15.90 | 0.0024 | 0.019 |
| NRL-1 | 29.40 | 73.60 | 4.00 | 0.40 | 0.90 | MR | 104.20 | 20.00 | 0.0034 | 0.047 |
| SAMSORG14 | 29.10 | 51.90 | 1.50 | 0.50 | 0.60 | MR | 136.70 | 18.20 | 0.0017 | 0.004 |
| SAMSORG16 | 22.50 | 59.10 | 2.80 | 1.30 | 0.70 | MR | 151.70 | 14.00 | 0.0012 | 0.009 |
| SAMSORG 17 | 46.40 | 45.00 | 1.70 | 0.80 | 0.70 | MR | 114.70 | 14.30 | 0.0015 | 0.012 |
| SAMSORG 3 | 70.40 | 13.30 | 0.00 | 0.00 | 0.70 | MR | 143.00 | 26.80 | 0.0034 | 0.028 |
| SAMSORG 38 | 16.40 | 57.70 | 1.40 | 1.20 | 0.60 | MR | 86.60 | 19.50 | 0.0047 | 0.050 |
| SAMSORG 42 | 16.40 | 67.50 | 0.00 | 0.00 | 0.60 | MR | 113.40 | 20.90 | 0.0035 | 0.060 |
| SAMSORG 43 | 19.30 | 51.60 | 0.80 | 0.60 | 0.70 | MR | 99.60 | 16.00 | 0.0008 | 0.005 |
| SAMSORG 44 | 21.60 | 54.50 | 1.70 | 0.00 | 0.60 | MR | 101.10 | 17.90 | 0.0041 | 0.049 |
| SAMSORG 45 | 45.00 | 53.70 | 0.00 | 0.00 | 0.60 | MR | 91.30 | 20.90 | 0.0023 | 0.022 |
| SAMSORG 46 | 19.30 | 61.40 | 1.40 | 0.50 | 0.60 | MR | 85.60 | 15.60 | 0.0014 | 0.036 |
| SAMSORG 47 | 51.60 | 64.30 | 0.00 | 0.00 | 0.70 | MR | 101.20 | 16.00 | 0.0039 | 0.042 |
| SAMSORG 48 | 16.40 | 67.50 | 0.00 | 0.00 | 0.40 | R | 113.40 | 20.90 | 0.0015 | 0.042 |
| SAMSORG 49 | 19.30 | 51.60 | 0.80 | 0.60 | 0.40 | R | 99.60 | 16.00 | 0.0036 | 0.047 |
| SAMSORG 50 | 21.60 | 54.50 | 1.70 | 0.00 | 0.50 | R | 101.10 | 17.90 | 0.0012 | 0.028 |
| ICSB 464 | 51.60 | 64.30 | 0.00 | 0.00 | 0.50 | R | 101.20 | 16.00 | 0.0053 | 0.053 |
| ICSL 71268 | 16.40 | 57.70 | 1.40 | 1.20 | 0.50 | R | 86.60 | 19.50 | 0.0022 | 0.026 |
| SOUMBA | 45.00 | 53.70 | 0.00 | 0.00 | 0.50 | R | 91.30 | 20.90 | 0.0026 | 0.028 |
| SAMSORG 51 | 16.40 | 67.50 | 0.00 | 0.00 | 0.40 | R | 113.40 | 20.90 | 0.0031 | 0.061 |
| ICSR 94032 | 19.30 | 51.60 | 0.80 | 0.60 | 1.40 | MS | 99.60 | 16.00 | 0.0002 | 0.004 |
| KSV 15 | 21.60 | 54.50 | 1.70 | 5.20 | 1.50 | MS | 101.10 | 17.90 | 0.0029 | 0.018 |
| TWIN SEEDED | 45.00 | 53.70 | 5.50 | 3.00 | 1.00 | MS | 91.30 | 20.90 | 0.0025 | 0.025 |
| KARURA MAIDUGURI | 19.30 | 61.40 | 1.40 | 0.50 | 1.30 | MS | 85.60 | 15.60 | 0.0031 | 0.036 |
| SAMSORG 40 | 51.60 | 64.30 | 4.50 | 2.50 | 1.20 | MS | 101.20 | 16.00 | 0.0016 | 0.019 |
| ICSL 71061 | 16.40 | 67.50 | 9.90 | 4.00 | 1.20 | MS | 113.40 | 20.90 | 0.0024 | 0.019 |
| ICSL 71168 | 19.30 | 51.60 | 0.80 | 0.60 | 1.40 | MS | 99.60 | 16.00 | 0.0034 | 0.047 |
| SAMSORG 39 | 21.60 | 54.50 | 1.70 | 3.50 | 1.40 | MS | 101.10 | 17.90 | 0.0017 | 0.004 |
| SAMSORG 6 (KSV-12) | 45.00 | 53.70 | 10.20 | 1.90 | 1.30 | MS | 91.30 | 20.90 | 0.0012 | 0.009 |
| SSV 20041 | 19.30 | 61.40 | 1.40 | 0.50 | 1.60 | S | 85.60 | 15.60 | 0.0015 | 0.012 |
| SRN 39-2 | 76.20 | 63.20 | 1.30 | 0.50 | 1.70 | S | 110.00 | 19.80 | 0.0034 | 0.028 |
| SSV20041 | 51.60 | 35.20 | 10.30 | 4.90 | 1.80 | S | 115.00 | 20.70 | 0.0003 | 0.003 |
| Mean | 35.90 | 57.80 | 4.00 | 1.70 | 0.90 | | 124.00 | 18.60 | | 0.003 |
| LSD (P=0.05) | 34.70 | 19.47 | 5.12 | 2.36 | 1.92 | | 34.65 | 4.91 | | 0.900 |
| P | <.001 | <.001 | <.001 | <.001 | 0.04 | | <.001 | <.001 | | <.001 |
| CV | 48.4 | 23.5 | 71 | 65.9 | 47.3 | | 62 | 42.5 | | 1.6 |

 

## DISCUSSION

Analysis of variance uncovered significant variation in the resistance levels of the tested sorghum genotypes to stem borer infestation. The highly significant differences ($P < 0.01$) among the genotypes across all agronomic and stem borer resistant traits point to the presence of genetic diversity. Certain genotypes demonstrate notable resistance, exhibiting minimal damage even when subjected to heavy pest pressure [10]. These genotypes hold promises as valuable genetic reservoirs for breeding initiatives aimed at cultivating stem borer-resistant sorghum varieties. Conversely, some genotypes displayed susceptibility to stem borer infestation, suffering severe damage and subsequent yield losses. Nevertheless, the degree of damage varied among susceptible genotypes, underscoring the existence of genetic variability in susceptibility levels. This diversity underscores the significance of screening diverse sorghum germplasm to uncover novel sources of resistance.

## CONCLUSIONS

The findings of this study underscore the importance of breeding for resistance to stem borer (*S. Calamistis)* infestation in sorghum cultivation in Nigeria. Elite sorghum genotypes exhibiting resistance to stem borer damage were identified, providing valuable resources for breeding programs. By incorporating resistance traits from these genotypes into breeding pipelines, it is possible to develop sorghum varieties with enhanced resilience to stem borer infestation, thereby improving crop productivity and farmer livelihoods in Nigeria. Further research is warranted to validate these findings under field conditions and to assess the stability of resistance across diverse agro-ecosystems.

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