Screening Sorghum Genotypes For Striga Resistance

Ardaly Abdou Ousseini[1,2,*], Mamadou Aissata Ibrahim[2], Fanna Maina[2], John Saviour Yaw Eleblu[1], Kwadwo Ofori[1]

[1]School of Basic and Applied Sciences, College of Agriculture / University of Ghana, West African centre of crop improvement (WACCI) Ghana

[2]Département de cultures pluviales, National Institute of Agricultural Research of Niger (INRAN) Niger

Abstract

In Niger, sorghum (Sorghum bicolor) is one of the most important staple crop for food and money. Despite the importance of the crop and its easiest adaptative capacity to dry, the crop is confronted to striga (Striga hermonthica), a plant parasite, which drastically hinder the productivity and causing yield loss between 20% to 80%. The best and easiest way to control and improve sorghum productivity is through the development of novel Striga resistance sorghum genotypes. The purpose of this study was to assess 20 sorghum genotypes from diverse country for striga resistance and grain yield capacity. Varieties with high yield average, medium size and resistance to Striga were found.

Research Article

Open Access &

Peer-Reviewed Article

DOI: 10.14302/issn.2639-3166.jar-22-4356

Corresponding author:

Ardaly Abdou Ousseini, School of Basic and Applied Sciences, College of Agriculture / University of Ghana, West African centre of crop improvement (WACCI) Ghana

Keywords:

Striga resistance, Phenotypic screening, sorghum, Yield, Niger.

Received: Oct 25, 2022

Accepted: Jan 01, 2023

Published: Mar 13, 2023

Academic Editor:

Abubaker Haroun Mohamed Adam, Department of Crop Science (Agronomy), College of Agriculture, Bahri University- Alkadaru-Khartoum -Sudan.

Citation:

Ardaly Abdou Ousseini, Mamadou Aissata Ibrahim, Fanna Maina, John Saviour Yaw Eleblu, Kwadwo Ofori, Screening Sorghum Genotypes For Striga Resistance, Journal of Agronomy Research - 5(1):16-23. https://doi.org/10.14302/issn.2639-3166.jar-22-4356

Introduction

In Niger, sorghum is mainly grown in harsh and dry environmental conditions, where rainfall is less than 200 to 300 mm per year [9]. Striga hermonthica, known as witchweed, is a major constraint affecting sorghum cultivation with yield losses of between 20 to 80% [11]. It is an obligate hemi parasite of cereal crops with a bright green stem, small leaves and purple flowers well visible in attacked fields [2].

Nonetheless, to inhibit Striga impact on sorghum, several resistance mechanisms have been successfully identified [8]. But, the best way to control the weed is to develop resistant genotypes through resistant gene introgression.

Thus, with the increase of Striga impact around the world, and Striga races variability, there are some sorghum genotypes which can better perform under high Striga infestation and give good yield better than other genotypes. In addition, under the same conditions, some genotypes cannot perform well. Some sorghum genotypes are highly susceptible to the weed resulting in grain yield reduction or a complete yield loss [4]. Therefore, there is a need to evaluate and select resistant lines which can perform well under Niger Striga infestation conditions. Hence, once the best genotypes are identified, they can be used in a sorghum introgression programme for Striga resistance.

The objectives of this study were to evaluate the twenty sorghum genotypes for Striga resistance, to identify a medium sorghum genotypes and grain yield capability estimation under Striga field infestation.

Materials and Methods

Study site geographical position

The field trial was conducted in Konni region at Wazir, INRAN Striga screening field located around 8 km from Konni and 3 km from the main road (RN1). Konni is located around 417 km from Niamey in the eastern part of Niger with a rainfall distribution of between 500 to 600 mm (INS, 2016). Wazir is an area characterized by an agricultural farming system where farmers grow different cash crops. It is a highly Striga infested area and was used since 1987 for Striga screening purposes by INRAN Niger.

Table 1. List and characteristics of fifteen documented Striga resistant sorghum and the five land races used for Striga screening at Konni (Niger).

Entry	Variety	Pedigree/Origins	Yield (T/Ha)	Specific Reactions To Striga
1	SRN39	Sudan	2	Striga resistant (Low strigolactone production)
2	El mota	Niger framers preferred land race	1.5	Early maturing/ unknown tolerance to Striga
3	P9401	SRN39X P954063	4	Striga resistant and early maturing
4	P9403	SRN39X P954063	3	Striga resistant and early maturing
5	Brahan	(Framida×SRN39) United States	/	Striga resistant
6	S35	ICRISAT	/	Striga resistant
7	F2-20	(MN1056 x 68-20) x 7410-195-1	3.5-5.0	Striga resistant
8	CE -151- 262	CE 90 x 73-71 (IS 12610)	2.0 – 4.3	Striga resistant
9	04-CZ-F5 P-52	Burkina	/	Striga resistant
10	ICSV- 1049	Burkina	5	Striga resistant
11	MDK (Matché Da Koumya)	Niger framers preferred land race	3	Good yield, late mature variety
12	CE -180-33	7455 (Senegal lines) x Naga white (Ghana)	2.8 – 5	Striga resistant
13	P9406	SRN39X P954063	/	Striga resistant and early maturing
14	P9405	SRN39X P954063	3.0 - 4.0	Striga resistant and early maturing
15	Mota Maradi	Niger framers preferred land race	2	Early maturing
16	Lignée 16	(TXN13)BC3F5-41	4.0 - 5.0	Striga resistant and good yield
17	Lignée 17	(AG-8XN13)BC3F5	5	Striga resistant and Good yield
18	Framida	ICRISAT	3.7	Striga resistant (Low strigolactone production)
19	Hakori Karoua	Niger framers preferred land race	1.0-1.5	Good yield
20	El tsedaoua	Niger framers preferred land race	1.5	Early maturing

Plant materials and methodology

Twenty sorghum genotypes (Table 1) were planted in a randomized complete block design (RCBD) with three replications. Thus, in the twenty genotypes fifteen are documented Striga resistant genotypes and the five remain are Niger local landraces susceptible to Striga but highly preferred by smallholder farmers. In the experiment, the seeds were sow at 3 cm of depth and the row length was 3 m. The rows are separate by 1.80 m, and in each row, 10 hills were planted separated by 0.30 m. Thus, during the planting process 1 g (16000 viable seed) [6] of Striga seed were added in each hill with 5 to 6 sorghum grains. For a better development, after 14 days of growth the extra plants were removed to remain only 3 to 4 plants per hill. After this process, 2 to 3 weeding sessions were done for removing the other weeds except the Striga plants.

Data collection and analysis

The data on sorghum crop components and Striga traits were collected in field. The sorghum data included plant vigor (Vg), 50% days to flowering (50% Flo), number of sorghum plants per hill (NPSorg), number of panicles (NPANI), plant height (HTR) in cm, 1000 grain weight (PoiGR) in g, and grain yield (Kg). The Striga emergence (EMR), the number of Striga plants emerged at 45, 60 and 90 days (SN45, SN60 and SN90) were collected as Striga related traits. The recorded data were transferred and analyzed using SAS (9.4). Thus, a normality test was performed in GENSTAT Edition 14, following by general linear model analysis and principal component analysis using SAS (9.4).

Results

Table 2. Association among Striga scores and sorghum growth and yield traits

	EMR	Flo	HTR	NPANI	NPSorg	NS45	NS60	NS90	PoiGR	Vig	Yield
EMR	-										
Flo	0.48 ns	-									
HTR	0.00 ns	0.13ns	-								
NPANI	0.12 ns	0.91**	0.02 ns	-							
NPSorg	0.01 ns	0.003 ns	0.68**	0.09 ns	-						
NS45	0.03 ns	0.36 ns	0.33 ns	0.45 ns	0.03 ns	-					
NS60	-0.69**	0.30ns	0.004 ns	0.26 ns	0.003 ns	0.79**	-				
NS90	-0.69**	0.30 ns	0.005 ns	0.14ns	0.004 ns	0.81**	0.98**	-			
PoiGR	0.41ns	0.86**	0.08 ns	0.80**	0.09 ns	0.77**	0.58 ns	0.52 ns	-		
Vig	0.03ns	0.04	0.34 ns	0.35 ns	0.38 ns	0.26 ns	0.22 ns	0.22 ns	0.47 ns	-	
Yield	0.71**	0.84**	0.58ns	0.05 ns	0.18 ns	0.41 ns	0.621*	0.75**	0.77 **	0.88**	-

Highly significant: **; Significant * EMR=Striga emergency; Flo= 50% flowering date; HTR = Plant height; NPANI= Panicles number; NPSorg=Hill number; NS45= Number of Striga plants at 45 days after planting date; NS60= Number of Striga plants at 60 days after planting date; NS90= Number of Striga plants at 90 days after planting date; PoiGR= 1000 grain weight; Vig= Plant vigor; Yield = grain yield Kg/ha; ns=non- significant

Association among Striga and sorghum agronomics traits

Linear correlation among traits varied from none, significant and highly significant correlations values. Number of Striga plants emerged after planting was negatively and highly correlated with number of Striga plants emerged at 60 days (r = -0.69) and Striga plants emerged at 90 days (r=-0.69). Thus, for the 50% days to flowering (Flo), a high significant correlation was observed with the panicles number, the grain weight, and the grain yield with respectively a correlation value r = 0.91, r = 0.86 and r = 0.84 (Table2). For the plant height (HTR) a high significant correlation was also observed with the sorghum plant number per hill (NPSorg) with a correlation value r = 0.68. The panicles number (NPANI) had a high correlation (r = 0.802) with the sorghum grain weight (PoiGR). The number of Striga plants emerged at 45 days (SN45) was highly correlated to the number of Striga plants emerged at 60 days (NS60), the number of Striga plants emerged at 90 days (NS90) and also the grains weight (PoiGR) with respective correlation values of r = 0.79, r = 0.81 and r = 0.77. The Striga plant emerged at 60 days was highly correlated at 98% (r = 0.98) to the Striga plants emerged at 90 days and it was also correlated to the sorghum grain yield at 62% (r = 0.62). The number of Striga plants emerged at 60 days (NS60), the number of Striga plants emerged at 90 days (NS90), the sorghum grain weight (PoiGR) and the sorghum plant vigor (Vig) were highly correlated to sorghum grain yield with respectively 68% (r = 0.68), 75% (r = 075), 77% (r = 0.77) and 88% (r = 0.88) of correlation values (Table 2).

Relative contribution of variables to genotypic variation

From the screening at Konni station, a principal component analysis (PCA) using 11 traits was performed to assess 20 sorghum genotypes from different countries. Among those 11 traits used, only the component 1, the component 2 and the component 3 were identified to have an eigen value higher (>)

Table 3. Variables, eigen values and eigen vectors for eleven sorghum and Striga traits in Konni (Niger)

Eigen Vectors			
Variables	PC1	PC2	PC3
Plant vigor	-0.17	0.08	0.61*
Striga emergence	-0.36*	0.07	0.11
Number of Striga plant at 45 days	0.32*	-0.28	-0.04
Number of Striga plant at 60 days	0.41*	-0.19	-0.05
Number of Striga plant at 90 days	0.41*	-0.172	-0.05
Number of sorghum plant hill	0.36*	0.05	0.24
50% flowering date	0.15	-0.09	0.71*
Plant height	0.36*	0.11	0.12
Panicle number	0.24	0.41*	-0.11
1000 grains weight	0.18	0.57*	-0.04
Grain yield	0.05	0.55*	0.04
Eigen value	4.75	2.36	1.58
%variance	42.3	21.4	64.7
Cumulative% variance	42.3	14.4	79.1

Eigen value >1; * Significant correlation;

than 1 under Striga infestation condition at Konni station. Thus, the three components contribute at 42.3% for the component 1, 14.4% for the component 2 and 79.1% for the component 3, in the total phenotypic variation among the 20 genotypes. The selected three Eigen values are explaining around 79.1% of the variation among the collected parameters in the experiment.

Therefore, depending on the correlation with the 11 traits (Sorghum and Striga traits) initially used, several significant correlation matrices were obtained (Table 3). Thus, concerning the sorghum plant vigor (Vg), a negative significant correlations r = 0.61 was found with of among the PC3. For the Striga emergence (EMR) a negative significant correlation of r = 0.36 was obtain in the PC1. In addition, concerning the numbers of Striga plants at 45 days, r = 0.32 of significant correlation value was observed in the PC1. The number of Striga plants at 60, was also significantly correlated with r = 0.41 to the PC1. For the number of emerged Striga plant at 90 days, a significant correlation value of r =0.41was obtain in the PC1. For the number of sorghum plants per hill (NPSorg), 0.36 of significant correlation value was obtain in the PC1. Thus, the flowering days is an important stage in the development and the multiplication process. At this side, PC3 obtain a significant correlation value of 0.71. In addition, from the plant height (HTR), the PC1 observe 0.36 of correlation significance. Thus for the sorghum panicle number (NPANI), 0.41 of significant correlation values was obtained in the PC2. The grain weight (PoiGR) obtained 0.57 of significant correlation value on the PC2. Finally, for the grain yield, 0.55 for the PC2 as significant correlation value was observed.

Contribution of principal components to variation among genotypes

The component plotting scores gave the results of the first two components, PC1 and PC2 on the genotypes distribution. In addition, each component was distributed into four environments comprising the environment 1 to the environment 4 (Fig1). The genotypes 04CZ-F5P-52, ICSV1049, MDK, CE-180 -33, Framida and Hakori Karoua were positively correlated to the environment 1 of the PC1. Thus, the genotypes El Mota, F2-20 and Eltsedaoua were positively correlated in the environment 2 of the PC1. Concerning the PC2, it is characterized by two environments (Env3 and Env4) distributed negatively and positively along the component. The environment 3 (Env3) was positively correlated to the PC2 and negatively correlated to the PC1 and comprise the genotype P9401, P9403, CE-151-262 and TXN13/ BC3F5. The last environment (Env4) contains more genotypes than the others environment (Env1, Env2, Env3) and are negatively correlated to the PC 1 and PC2. The figure 3 give the distribution of the different genotype contained on the environment 4 (SRN39, Brahan, S35, P9406, P9405, Mota Maradi, and AG8N13/BC3F5).

Concerning the component one and the component three, at this side, the environment 1 of the component 1 contain the genotype SRN39, CE-180-33, El tsedaoua and were positively correlated to the environment one (Fig. 2). Thus, in the environment 2 correlated positively there are six genotypes represented by the genotype F2-20, 04-CZ-F5P-52, ICSV-1049, MDK, FRAMIDA, Hakori Karoua. For instance, the environment 3 was positively and negatively correlated respectively to the component 1 and the component 3 with the genotypes P9401, P 9403, Brahan, S35, CE-151-262 and the genotype P9405. In addition, the last environment correlated negatively to the component 1 and the component 3, four genotypes, were found, the SRN39, P9406, Mota Maradi and (AG-8XN13) BC3F5 (Fig. 2).

For the component two and the component three, the environment 1 was positively correlated to the component 2 and contain the genotype El Mota and El tsedaoua. Concerning the environment 2 of the component 2 was positively correlated with the genotype P9401, P9403, F2-20, CE-151-262, and the genotype (TXN13) BC3F5-41. Thus, the environment 3 is negatively correlated to the component 2 and positively correlated to the component 3 and contain Brahan, S35, 04-CZ-F5P-52, ICSV1049, MDK, P9405, FRAMIDA, Hakori Karoua (Fig. 3).

Discussion

The main objective of the study was to assess 20 sorghum genotypes under Striga infestation at Konni station in Niger for Striga resistance and determine Striga impact on sorghum growth and agronomic parameters. Thus, the normality test performed was significant along the recorded data. In addition, the general linear analysis (GLM) with the different mean squares obtained on the sorghum attributes and the weed parameters, were also significant. Moreover, this obtained result show a large variation among the genotype's and confirm the existence variability between them. The correlation study undertaken sort the interaction between the different variables involved in the experiment to better guide the breeders. For instance, correlation study deeply gave more information on the bidirectional relationship of the characters [10]. Thus, it is useful to segregate the genotypes with good yield resistant to Striga and the susceptible genotypes. Therefore, the results will well guide the breeding process to better select the good material for the next hybridization study. So, the correlations found between the Striga emergence date (EMR) and Striga plants numbers at 60 and 90 days (NS60 and NS90), were highly negatively correlated for both of them. The negative correlation is explained by the fact that, when the Striga emergence start early or late it decrease the Striga plant number at 60 and 90 days. Obviously, if the correlations were positive, it should increase the plants numbers at 60 and 90 days. For the 50 % date to flowering, a high positive correlation was observed with the number of panicles (NPANI), the 1000 grain weight (PoiGR) and the yield. At the genotypic level, the result gave more explanation on the relationship between the flowering times and the yield attributes and also confirmed the previous study made by [7]. The earlier the flowering time lower will be the yield. So, the positive correlation shows that late flowering is better for obtaining a greater number of panicles, a high grain weigh and high yield contrary to what was found by [3] and [10]. This result will orient the breeder to select the best genotypes. In addition, the correlation between the panicle numbers and the grain weight was positively highly significant, meaning, higher panicle numbers result in higher 1000 grain weight. Concerning the number of Striga plants at 45 days (NS45), it was positively highly correlated to the number of Striga at 60 days and 90 days. Thus, when the number of Striga plants at 45 days is high, the number of Striga plants at 60 and 90 days and will be equally high and inversely when the number is less, there will also less number of Striga plants at 60 and 90 days [1]. In addition, the 1000 grain weight and the yield were positively correlated which is well known in sorghum crop [12]. Therefore, when the grain production is well distributing it will highly positively impact the yield. They also confirmed the high positive correlation between the plant vigor (Vig) and the yield. In addition, the PCA analysis identified three components with an

Eigen values greater than one. Thus, the varieties located in the environment 3 of the component 2 have a higher negative correlation with the component 1. However, in this environment Striga emergence starts earlier compared to in the other's environments 3. That means the genotype P9401, P9403, Brahan, S35, CE-151-262 and P9405 were under high Striga emergence impact with high grain yield. The highest plant height (HTR) were located in the environment 2 of the component 1. In this environment (ENV2), the genotype El Mota, F2-20 and El tsedaoua possess a high height compared to the others genotypes. The component 2 was positively correlated to the number of panicles (NPANI), the 1000 grain weight (PoiGR) and the grain yield in the environment 3 with high Striga emergence impact and concern the genotype P9401, (TXN13) BC3F5-41, CE-151-262 and P9403. In the environment 3 of the component 3 positively correlated to the plant vigor and the 50% date to flowering (Flo), the Striga emergence was high in this area and contains the genotype P9401, P9403, Brahan, S35, CE151-262, 04-CZ-F5P-52, ICSV-1049, MDK, P9405, (TXN13) BC3F5-41, FRAMIDA, and Hakori Karoua. Those varieties are characterized by a better plant vigor and are early flowering genotypes. In addition, the component 3, was also negatively correlated to the number of Striga plants number at 45, 60 and 90 days after the planting date. It concerned SRN39, CE-180-33,

P9406, Mota Maradi and the genotype (AG-8XN13) BC3F5 highly infested by the weed with less grain yield observed. This environment contains a high Striga plants number and confirmed the presence of tolerant genotypes with high grain yield in these area.

Conclusion

The present study made on the assessment of striga impact on sorghum attributes and striga traits, put in light the variability among the twenty sorghum genotypes and their performance's against the weed. The PCA analysis used, have grouped the different variables according to their correlations and their respective comportments. So through the obtained results on the three components, we found that the genotype P9401, P9403, Brahan, S35, CE 151-262, P406, and TXN13/BC3F5-41 are high yielding genotypes with medium height, good panicles numbers, good grain weight are resistant to the weed. Those promising genotypes can be easily used in a hydration breeding program for improving some local land races highly susceptible to striga but highly appreciated by smallholder's farmers.

References

1. Abdalroof, M., Eltayeb, A., Abusin, R., 2017. Effects of Inter-cropping and an Herbicide on Management of Striga hermonthica on Sorghum. Asian Research Journal ofAgriculture, 5, 1-10.
2. Kouakou, C. K, Louise, A., Zoro, B. I, René, A., 2015. Distribution et infestation des espèces de Striga sur les cultures céréalières en Côte d'Ivoire. Cahiers Agricultures. 24, 37-46.
3. Liang, G. H. L., Overley, C. B and Casal, A. J., 1969. Inter-relationships among agronomic characters in grain sorghum. Crop Science, 9, 299-302.
4. Mesfin, T., Mohammed, J., Abuhay, T., Feyera, M., 2014. Skip-row planting of maize and sorghum in semi-arid Ethiopia. African Journal of Plant Science, 8, 140-146.
5. Millennium Challenge Account – Niger (MCA-Niger) 2020 https://www.mcaniger.ne/tag/konni/. Omanya, G. O., Haussmann, B. I. G., Hess, D. E., Reddy, B. V. S., Kayentao, M., Welz, H.G., et al. (2004). Utility of indirect and direct selection traits for improving Striga resistance in two sorghum recombinant inbred populations. Field crop res. 89, 237– 252.
6. Patel, D. V., Makne, V. G., and Patil, R., 1994. Interrelationship and path coefficient studies in sweet stalk sorghum. J. Maharashtra Agric. Univ, 19, 40-41.
7. Samia O., Mohammed. M., Migdam E. and Abdel El Gabar E., 2014. Screening Sorghum for Resistance to Striga Hermonthica (Del.) Benth. Nova Journal of Medical and Biological Sciences, 2, 1-7.
8. Schlegel, A.J., Y. Assefa, L.A. Haag, C.R. Thompson, J.D. Holman, L.R. Stone. 2017. Yield and soil water in three dryland wheat and grain sorghum rotations. Agron. J, 109-227.
9. Sowmy, H.H., Brunda, S.M., Deepak Kumar, G.S., Vidya, G., Kamatar, M.Y., 2015. Estimation of Correlation Coefficients and Path for Yield Traits in Grain Mold Tolerant F3 Progenies of Sorghum.

International Journal of Science Research (IJSR), 2319-7064.

10. Teka, H.B., 2014. Advanced research on Striga control: A review. African Journal of Plant Sciences, 8(11), 492-506.
11. Yagoub, S. A., Mohamed, E. A., Elshiekh, I., Awad, A. A., (2018). Correlations among grain yield and yield attributes in sorghum at different water harvesting techniques. Journal of Natural Resources and Environmental Studies, UKJNRES, 5(1), 13-25.
12. Zhang, Z., & van Kleunen, M., 2019. Common alien plants are more competitive than rare natives but not than common natives. Ecology Letters, 22, 1378–1386.