ISSN No:-2456-2165

Evaluation of West African Sorghum Varieties for Resistance to Striga in the Sudano-Sahelian Zone of Mali

Aly Kansaye[1,*], Laya Kansaye[1], Abdou Mallé[1], Baloua Nebie[2], Chaka Donigolo[1]
[1] Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA) de Katibougou, Mali
[2] International Crops Research Institute for Semi- Arid Tropics (ICRISAT), Mali

Abstract:- Sorghum (Sorghum bicolor), grown in semi-arid areas of Africa and Asia, is food source for millions of people. This crop is subject to several constraints, including Striga hermonthica, the most common parasitic plant in sorghum fields in the Sahelian and Sudanian zone. Striga causes significant damage to this crop. To control this pest, a study entitled "Evaluation of West African sorghum varieties for resistance to striga in the Sudano-Sahelian zone of Mali" was carried out in the research station of Samanko (ICRISAT). The objective of the study was to identify striga resistant and/or tolerant varieties compared to local controls and to describe the evolution of the striga population according to the development stage of these varieties. For this study, 126 varieties from several west African countries and two local varieties as controls were used. Experimental design was Alpha Lattice system. The following characteristics were measured: plants vigor of sorghum, date of 50% flowering for sorghum, number and vigor of striga at different stages of sorghum development. Results showed, that half of varieties had good to excellent vigor, 48% had intermediate vigor and only 2% of varieties had very poor vigor at emergence. Then striga resistants' varieties were identified, namely: Kouria, Dambima White, DORADO; Lata//Ridb-8-9-1-1-bulk, SAMSORG 45, Framida, Kapaala (ICSV 111), SAMSORG 6, SURENO, NGUINTHE. The population of striga was less important in the plots of these varieties i.e., 8 to 58 plants compared to the resistant control Soumalemba in which plot the population of striga was composed by 68 plants.

Keywords:- *Varieties, Sorghum, West Africa, resistance, striga, sudano-sahelian.*

I. INTRODUCTION

Sorghum (*Sorghum bicolor* [L.] Moench), native in Africa [1], is among the most widely grown cereals in the world. It occupies the fifth place in the world in terms of production after wheat, rice, maize and barley [1], [2]. Sorghum is one of the main food crops in the poorest areas of the world where food security is most at risk. It is adapted to hot and dry agro-ecological zones, where it would be difficult to grow other forms of cereals [3]. In Africa, its production reaches 27 million tons. The world production is estimated about 57 million tons per year. African production represents about 47% of world production [4]. Mali's production was estimated at about 1393826 tons for 1,585,986 ha cultivated in 2017, with an average yield less than one ton per hectare [4]. In Mali, sorghum is grown in the center and south of the country under rainfall conditions between isohyets 400 and 1300 mm and under recession conditions in the north. It is also grown in different agro-ecological zones. Sorghum, is a drought tolerant crop, and adapted to high temperatures, low fertility (especially low phosphorus), acidic, deep sandy or deep black clay soils (vertisols) [5]. However, sorghum cultivation is hampered by certain constraints among others insect damage, diseases, insufficient and poorly distributed rainfall, low soil fertility [6] and especially damage caused by striga attack.

Striga is one of the main limiting factors for sorghum production in the Sahel in general and in Mali in particular. Among the various weeds identified across the Sahel, striga is the most widespread and damaging parasitic plant [7], thus according to [8] *Striga hermonthica* is the most common species (97, 1%) in cereal crops, followed by *Striga aspera* (2.0%) and *Striga asiatica* (0.9%). It is a real problem in several regions of the African continent [9] and capable of reducing host crop yields more than half, and sometimes causes 100% crop loss [10]. The extent of yield losses suffered by crops related to the parasitic lifestyle of striga [9]. Striga represents therefore a threat to food' security in infested areas [8]. The susceptibility of local varieties to striga is one of the main causes of low sorghum yield in the Sahel. In order to respond to susceptibility of local varieties to *Striga hermonthica* this study entitled: "Evaluation of West African sorghum varieties for resistance to striga in the Sudano-Sahelian zone of Mali" was conducted. The objectives of this study are to: - improvement sorghum' productivity and yield stability, and - identify resistant and/or tolerant varieties to striga.

II. MATERIALS AND METHODS

A. Materials

- *Test location*

The trial was conducted in the agricultural research station of ICRISAT located in Samanko at 25 km at southwest of Bamako Mali (12°5' North East Attitude, 8°5' West Longitude).

ISSN No:-2456-2165

➢ *Plant material*

The plant material was constituted of striga species and 128 sorghum varieties, including 2 controls (a susceptible variety "Lata" and a resistant variety "Soumalemba"). The material included lineages from different breeding programs in West Africa including: Mali (69 varieties), Burkina Faso (13 varieties), Nigeria (18 varieties), Senegal (13 varieties), Ghana (3 varieties), Togo (4varietes) and Niger (3 varieties). These varieties are the most used in different breeding programs and/or by sorghum producers in these countries.

➢ *Technical material*

The material used to carry out the work was as follows:

- a tractor for ploughing the plots;
- a tape measure, ropes and stakes for the delimitation of the plots;
- an electric scale for the weighing of the striga seeds;
- a ruler of seedling with a spacing of 0,30m between the seed pockets and measure the height of the plants;
- a hoe used for sowing and the daba for weeding.

Di-ammonium phosphate DAP (18-46 -0) was used as a base fertilizer at a rate of 100kg/ha, i.e. 3kg for 337.5 m2. Apron star (thiamethoxan, metalaxyl-M, difenoconazole), a fungicide and insecticide were used for the treatment of seeds at a rate of 4g per 10kg of seed.

B. Methods

➢ *Experimental design*

The experimental design was Alpha Lattice system with two-repetitions Each repetition was composed of 16 blocks and each block was subdivided into eight plots. A plot consisted of one line with 3m long. The spacing between seeding pockets was 0.30 m, i.e. 10 pockets per line. The total area of the field was 337.5 m2 (18.75mx18m) and the distance between two plot was 0.75m.

➢ *Technical itinerary*

A flat ploughing was carried out using a motorized plough followed by ridging. Di-ammonium phosphate, DAP (18-46 -0) was used as a base fertilizer at a rate of 100kg/ha, or 3kg per 337.5m2.

- *Layout Staking*

The operation consisted in making the delimitation of the trial in repetition, blocks and elementary plots using a tape measure, a rope and iron stakes on which the field labels are attached.

- *Seed preparation*

The seed was treated with Apron star (thiamethoxan, metalaxyl-M, difenoconazole), an insecticide-fungicide at the rate of 10 g per 4 kg of seed and distributed in mini-grips for each plot. Each mini-grip was labeled with the plot number and the entry number.

- *Sowing*

The operation consisted first of classifying the seeds by entry and by repetition. The sowing was done manually with a spacing of 0.75m between the ridges and 0.30m between pockets at a rate of 3 to 5 seeds per pocket and 5cm depth.

- *Hoeing and weeding*

Only one weeding was done two weeks after seeding before striga emergence followed by hand weeding. The weeding was done at the same time as the demarcation, keeping two plants per pot.

➢ *Phytosanitary treatment*

The phytosanitary treatment was done twice a week with EMACOTT at a dose of 200-250g/ha diluted in 15 liters/ha in order to fight against the attacks of insects in the emergence and the run-up stages on all plots.

➢ *Infestation of the area with striga*

This operation has begun with the leveling of the ridges with the dabas then leveled by leaving a ridge between the lines, a furrow of infestation has been traced on each plot. The infestation was done artificially by mixing striga seeds and fine sand with a dose of 0.80g of striga seeds mixed with 250g of sand, corresponding to 35000 viable striga seeds per m2. The mixture (striga seeds/sand) was spread in a furrow 3 m long, 30 cm wide and 5 cm deep. Sorghum was planted two weeks after infestation, the period necessary for preconditioning of striga.

Fig 1:- Operation of soil infestation with striga

ISSN No:-2456-2165

➢ *Observation*
➢ *Observations On Sorghum*
- *Vigor at emergence*

The vigor at the emergence was evaluated 15 days after sowing by using a score scale from 1 to 5 (1: very bad, 2: bad, 3: medium, 4: good, 5: excellent).

- *Date of 50% flowering*

The 50% flowering date was determined visually by passing through the plots every two days from the appearance of the first panicle until 50% of the plants had flowered.

- *Plant height*

Plant height was measured from the top of the panicles to the ground with a ruler on 2 randomly selected plants in each plot at the doughy grain stage.

- *Observations on striga*

Striga emergence: The date of emergence was determined from the date of appearance of the first striga plant on the trial.

- *Counts and vigor of striga at emergence:*

A total of five counts were made. The first count was conducted at two weeks from the date of emergence of the first striga plant in the trial and the rest of the counts were conducted every 2 weeks from the first.

- *Mean Vigor:*

It was determined by the dominant size, the presence of branch and the number of branches.

- *Flowering date:*

was determined by the apparition of the first flower of striga plants on the plot.

Source	d.d.l.	SCE	m.s.	cv	*Prob*
Repetition	1	12.94	12.94	0.164	0.685
Block	15	1905.41	127.02	1.613	0.081
Variety	127	27723.58	220.02	2.795	4E-08
Residual	110	8659.29	78.72		
Total	252	38301.24	151.98		

Table 1:- Summary of the Striga Vigor Rating Scale

➢ *Statistical Data Analysis*

Excel and GenStat ed. 12 software were used for statistical analysis. The parameters analyzed were: vigor at emergence, delay 50% flowering, sorghum plant height, mean vigor and number of striga per plot. Data were subjected to analysis of variance, and varieties were compared using the multiple comparison test.

III. RESULTS

A. Sorghum vigor at emergence

The results show that 10% of varieties had excellent vigor, 40% good vigor, 38% acceptable vigor, 2% weak vigor and 10% of varieties recorded poor vigor (Figure 2). The controls showed good vigor.

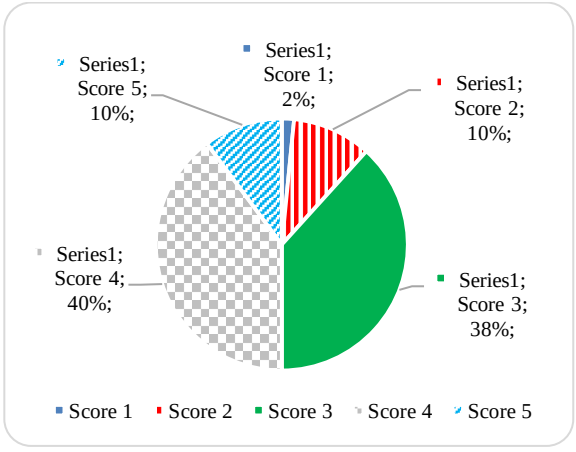

Fig 2:- Sorghum vigor at emergence

B. Sorghum 50% flowering date

The analysis of variance showed a significant difference between the different varieties (Table 2). The delay between sowing and 50% heading ranged from 64 days for DORADO to 120 days for SURENO with an average of 92 days. The control Lata emerged earlier than the other varieties, at 83 days. The soumalemba control spiked 116 days after sowing. Most of the varieties were lates in the trial and this is explained by the fact that the soil was poor compared to the usual yield trials and also because of the effect of striga which delays heading.

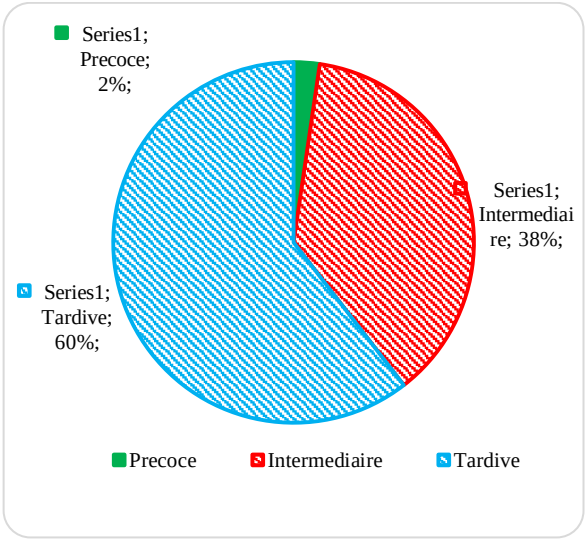

Fig 3:- Flowering date 50%

ISSN No:-2456-2165

Source	d.d.l.	SCE	m.s.	cv	*Prob*
Repetition	1	12.94	12.94	0.164	0.685
Block	15	1905.41	127.02	1.613	0.081
variety	127	27723.58	220.02	2.795	4E08
Residual	110	8659.29	78.72		
Total	252	38301.241	151.98		

D.D.L = D.D.L = degree of freedom; SCE= sums of squares; MS= mean ; CV= coefficient of variation; PROB = probability.

Table 2:- Sorghum 50% Heading Delay

C. Resistance and tolerance of the varieties to striga

➢ *Emergence of striga (sorghum sowing time - emergence of the first striga)*

Analysis of variance has not shown significant differences between varieties. On average, striga appeared 46 days after sowing in Sorghum. The minimum duration was observed in the variety F2-20 with 26 days after sowing and the maximum duration in ICNSL2014-002-5 with 65 days after sowing. On the control variety (Resistant) the striga appeared 39th DAS rather than on the average varieties (46 DAS) and on the susceptible variety the appearance of striga was observed at 57th DAS.

DAS: days after sowing

➢ *Number of striga plants*

The analysis of the results showed no significant difference between the varieties for the number of striga emerged at the first and second count, carried out respectively on the 42nd and 56th day after sowing of the sorghum. Significant differences were observed at the third count, the70^{e} days after sowing with a probability (Pr) of 0.0107. The differences were very highly significant at count 4 and 5 with a probability less than 0.001. The lowest number of striga was observed on 12 varieties (from 8 to 66 feet of striga): Kouria (Burkina Faso) Dambima White (Ghana), DORADO (Senegal &Ghana); Lata//Ridb-8-9-1-1-bulk (Mali), SAMSORG45 (Nigeria), Framida (Mali, Kapaala (ICSV 111) (Ghana), SAMSORG6 (Nigeria), SURENO (Senegal), NGUINTHE (Senegal). And the highest numbers of striga were observed on 110 varieties a number that varied from 297 and 379 feet of striga at the last count, at 98 days after sowing. These varieties were less resistant than the resistant control; 80 varieties or 63% of the entries evaluated had less striga than the sensitive control Lata which recorded 295 feet (Figure 4).

Source	d.d.l.	SCE	m.s.	cv	*Prob*
Repetition	1	12.94	12.94	0.164	0.685
Block	15	1905.41	127.02	1.613	0.081
variety	127	27723.58	220.02	2.795	4E-08
Residual	110	8659.29	78.72		
Total	252	38301.24	151.98		

D.D.L = D.D.L = degree of freedom**; SCE=** sums of squares; MS= mean**; CV=** coefficient of variation**; PROB =** probability.

Table 3:- Number of Striga Plants in the 4th and 5th Counting

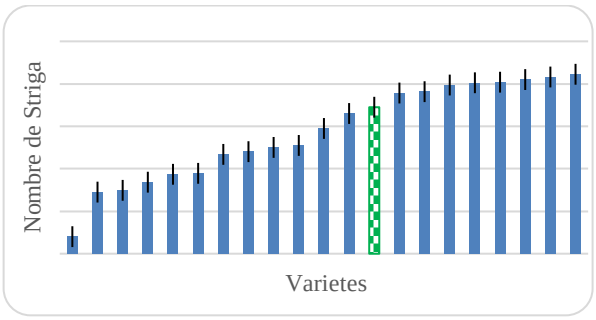

Fig. 4:- Number of striga plants on the varieties which were compared to the resistant control (Soumalemba)

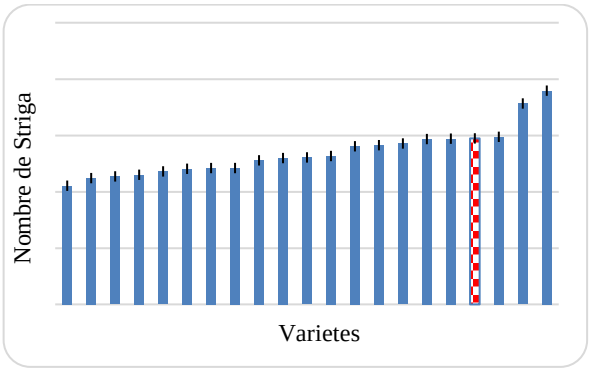

Fig. 5:- Varieties with the highest number of striga plants compared to the susceptible control and varieties that had less striga

➢ *Vigor of Striga in the 4th and 5th counting*

Striga vigor was scored on a scale of 1 to 9. The observed vigors ranged from 2 to 5 and the analysis showed no significant difference between varieties. Three varieties showed excellent vigor and the controls recorded a good vigor of 4. Thus, 2% of the varieties scored 5.4% of the varieties scored 1.20% of the varieties scored 2.24% of the varieties scored 4 including the two controls and 50% of the varieties recorded 3.

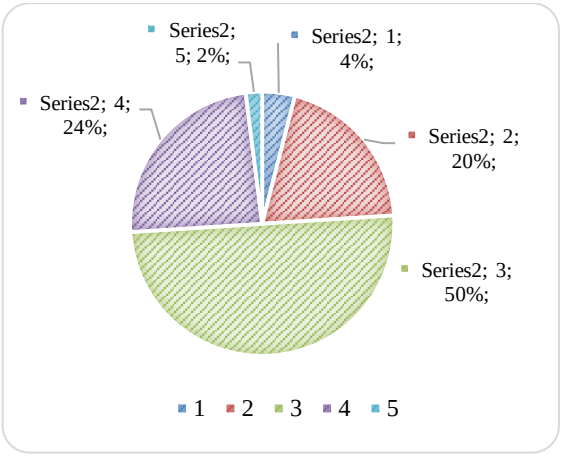

Fig. 6:- Striga vigor at last counting

Legend: 1= no branch; 2 = no branch; 3 = with branch; 4 = ≤ 5 branches; 5 = > 5 branches

ISSN No:-2456-2165

IV. DISCUSSION

The results of the study showed that the varieties (PGND12C2-S1-266-2-SB2-5-SB-SB-1-SB, SAMSORG) obtained an excellent score 5 and 30 varieties had a good score 4 at emergence including the resistant control Soumalemba. The first striga emergence was observed in F2-20 at 26 days and the last emergence in ICNSL2014-002-5 at 65 days after sowing. These varieties have shown a relatively high susceptibility to striga emergence. This observation is in agreement with that of [11] who stated that susceptible varieties stimulate striga emergence after a few days by emitting a substance. the lowest number of striga was observed at the last count on the variety Kouria and the highest number on the variety Kala Wassale which had 8 and 379 striga plants respectively. However, it is important to mention that the varieties FAOUROU, Grinkan Yerewolo and Kala Wassale had more striga with respectively 297, 357 and 379 plants against 295 for the susceptible control Lata. Varieties Kouria, Dambima White, DORADO; Lata//Ridb-8-9-1-1-bulk, SAMSORG 45, Framida, Kapaala (ICSV 111), SAMSORG 6, SURENO, NGUINTHE, had less striga with 8 to 58 plants of striga compared to the resistant control (soumalemba) with 68 striga.According to [10], later the emergence of the pest with a variety, the more vigorous that variety becomes and the more likely it is to resist or withstand striga attack. *Striga hermonthica* emergence was lower in resistant varieties. These results are consistent with those of [12], [13] that the use of improved sorghum varieties seems to favor the resistance of these plants because according to [14], the germination of striga seeds is conditioned by the release of the compound called strigolactone in the root exudates of host plants. According to [15], [16] this compound is slightly produced in tolerant plants. The delay between sowing and 50% flowering varied from 64 (DORADO) to 120 (SURENO) days after sowing with an average of 92 days. This difference seems to be due to the earliness of some varieties. According to [17], early varieties escape severe striga attack because they complete their cycle while the pests have not yet arrived at maturity.

V. CONCLUSION

The results of the study have allowed to identify 10 resistants varieties namely: Kouria, Dambima White, DORADO, Lata//Ridb-8-9-1-1-bulk, SAMSORG45, Framida, Kapaala (ICSV 111), SAMSORG 6, SURENO, NGUINTHE. These varieties were more resistants compared to resistant control (soumalemba). DORADO and SURENO are early, resistant varieties that can be recommended for use in farmer-based cropping systems. The use of tolerant varieties in cropping systems can be an important component of striga control strategy.

REFERENCES

[1]. J. Chantereau, J.-F. Cruz, A. Ratnadass, G. Trouche, et G. Fliedel, *Le sorgho*. Éditions Quae, 2013.

[2]. Gakou, « Evaluation des nouveaux hybrides de sorgho pour leur potentiel de rendement et leur résistance au striga », Memoire, IPR/IFRA de Katibougou, 2018.

[3]. FAO-ICRISAT, « L'économie mondiale du sorgho et du mil: faits, tendances et perspectives », *FAO, Rome*, 1997.

[4]. FAOSTAT, « La production agricole », 2018.

[5]. E. Weltzien, « Le sorgho en Afrique : opportunités et priorités de recherche », 2014.

[6]. Traoré, « Caractérisation agro morphologique de 105 descendances (BC1F6) de sorgho à haute digestibilité dans la zone soudanienne du Mali », Mémoire de fin de cycle, IPR/IFRA de Katibougou, 2016.

[7]. F. S. Bocoum et M. D. Thomas, *La lutte intégrée contre les ennemis des cultures vivrières dans le Sahel*. Montrouge : John Libbey Eurotext, 1992.

[8]. C. K. Kouakou, L. Akanvou, I. A. Z. Bi, R. Akanvou, et H. A. N'da, « Distribution des espèces de Striga et infestation des cultures céréalières dans le nord de la Côte d'Ivoire », *Cahiers Agricultures*, vol. 24, nº 1, p. 37-46, 2015.

[9]. A. Olivier, « Le striga, mauvaise herbe parasite des céréales africaines : biologie et méthodes de lutte », *Agronomie*, vol. 15, nº 9-10, p. 517-525, 1995.

[10]. T. C. SawaDogo, H. TRAORE, D. YONLI, J. I. BOUSSIM, et M. TUINSTRA, « Evaluation de la résistance de lignées mutantes de sorgho contre Striga hermonthica (Del.) Benth. au Burkina Faso: Screening of sorghum mutant lines for resistance to Striga hermonthica (Del.) Benth. in Burkina Faso », *Sciences Naturelles et Appliquées*, vol. 2, 2016.

[11]. P. Chabalier, V. Van de Kerchove, et H. Saint Macary, *Guide de la fertilisation organique à La Réunion*. CIRAD, 2006.

[12]. H. Ranaivostsilavo, « Effets des fertilisants chimiques et du système sous couvert végétal sur l'attaque de striga asiatica L. Kuntze aux cultures de maïs Zea mays L variété plata à Kianjasoa », Mémoire de fin d'étude en vue de l''obtention d'un diplôme de master II, Université d'Anatananarivo-Madagascar, 2017.

[13]. N. H. Ravelon janahary, « Etude de l'effet des systèmes de couverture végétale vive et morte (Vigna unguiculata et Stylosanthes sp.) sur la croissance des plantes de maïs améliorées (Zea mays L.) face à l'attaque de la plante parasite Striga asiatica (L.) Kuntze », Mémoire Master II, Parcours Physiologie et Biotechnologie Végétales, Université d'Antananarivo, 2017.

[14]. F. F. Bebawi et R. E. Eplee, « Efficacy of ethylene as a germination stimulant of Striga hermonthica seed », *Weed Science*, vol. 34, nº 5, p. 694-698, 1986.

ISSN No:-2456-2165

[15]. C. E. Cook *et al.*, « Germination stimulants. II. Structure of strigol, a potent seed germination stimulant for witchweed (Striga lutea) », *Journal of the American Chemical Society*, vol. 94, nº 17, p. 6198-6199, 1972.
[16]. O. Ouédraogo, T. D. Kaboré, D. R. Noba, et S. Traoré, « Polygala rarifolia DC., plante faux hôte du Striga hermonthica (Del.) Benth », *Journal of Applied Biosciences*, vol. 123, p. 12346-12353, 2018.
[17]. M. Naitormmbaide, K. Djondang, V. J. Mama, et M. Koussou, « Criblage de quelques variétés de maïs (Zea mays L.) pour la résistance au Striga hermonthica (Del) Benth dans les savanes tchadiennes », *Journal of Animal & Plant Sciences*, vol. 24, nº 1, p. 3722-3732, 2015.